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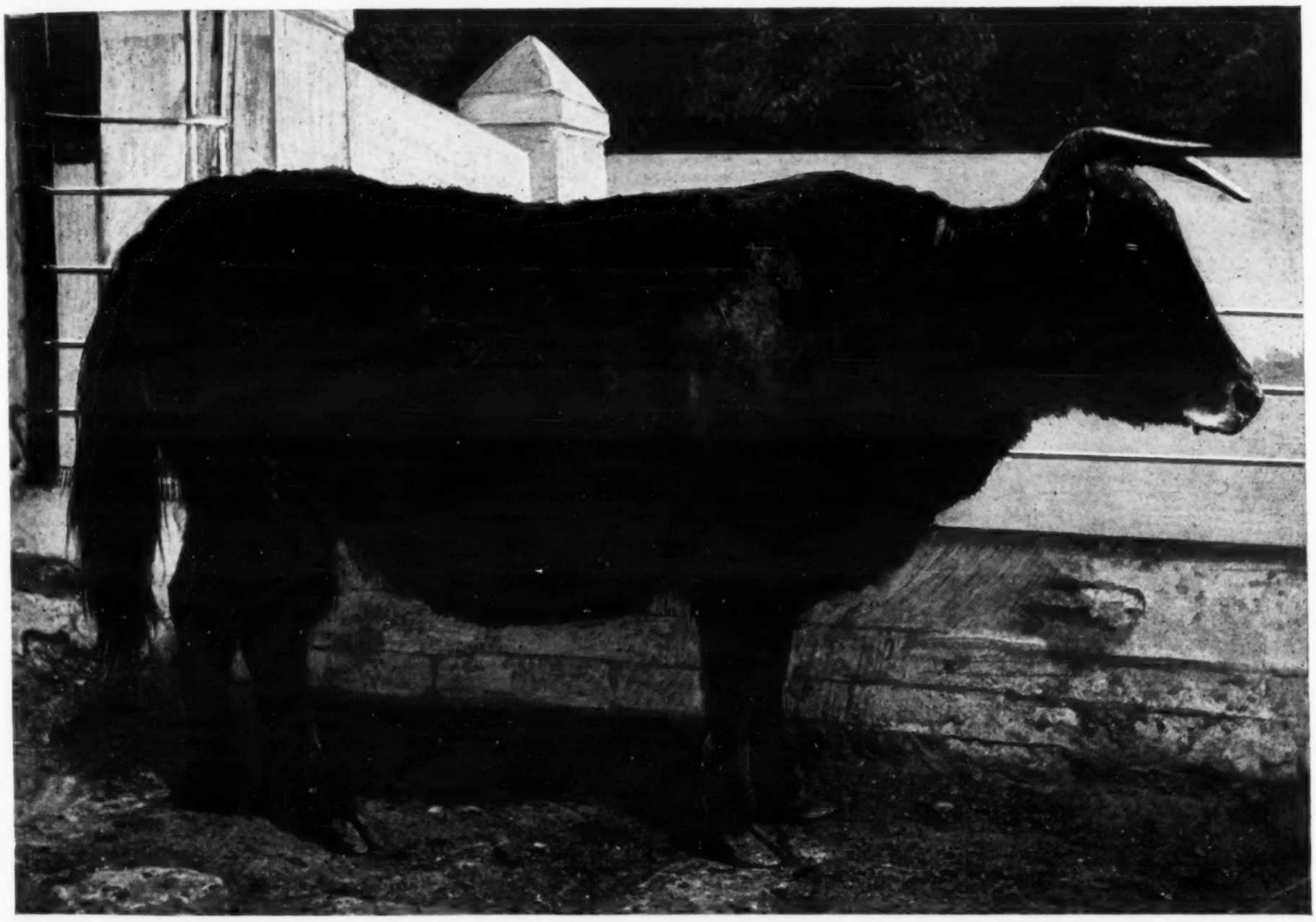

A ZEBU-YAK HYBRID

(See page 297)

The First Plant Patent

Ruby Seed-Coat Color in Peas

What Governs Population Growth?

Induced Melanism in Moths

VOLUME 22 OCTOBER, 1931 NUMBER 10

The American Genetic Association

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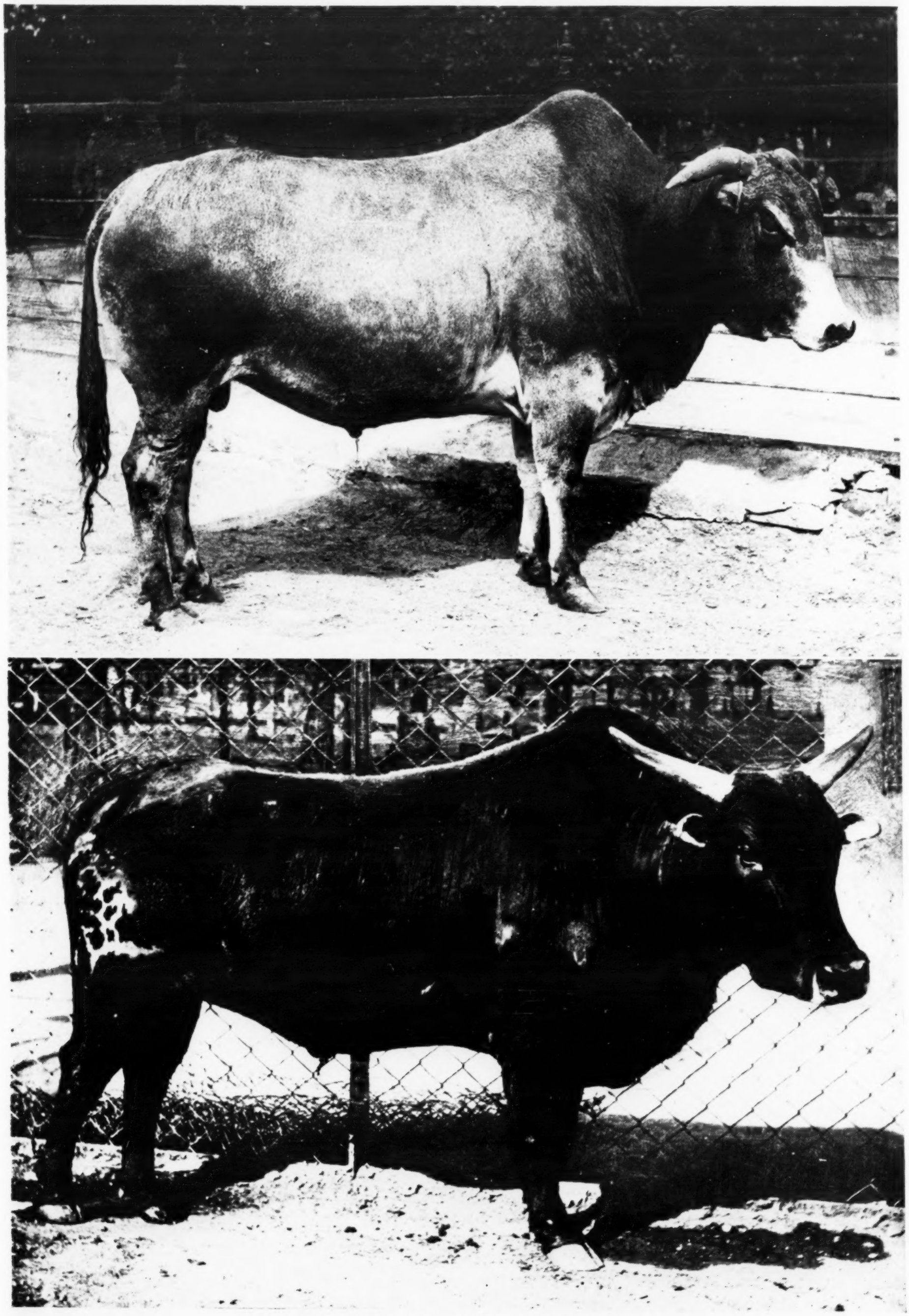


HYBRIDS OF ZEBU AND YAK

Frontispiece

These animals are backcrosses between a hybrid zebu-yak female and a zebu male. In this cross the females are fertile and the males are sterile, both in the first generation and in the backcross, so that backcrosses to one of the parent species are necessary. In this cross between two genera differing greatly in many characteristics, there is definite evidence of segregation of a number of characters. Both these bulls ("Son of Ganges," above; "Bunyan," below) are sons of "Paria" (Figure 8) by a full blooded zebu bull (Figure 1).

ZEBU-YAK HYBRIDS

Sterility of Bulls, Fertility of Cows and Material on the Genetics of Zebu-Yak Hybrids

M. M. ZAWADOWSKY

Moscow Laboratory of Experimental Biology

IN 1926 we published a brief statement concerning the results of the crossing of the zebu and the yak in the Zoological Park at Moscow. During recent years, in spite of many difficulties in carrying out this work, we have gathered some additional material which may be of some importance with regard to the genetics of cattle.

The initial material, as we have already mentioned, was obtained by crossing the zebu bull "Ganges" (Figure 1) with a yak cow. From this crossing there came the cow "Paria" (Figure 8) which was crossed repeatedly with her father "Ganges" during ten years. Eight calves (Frontispiece and Figures 13 and 14) are the result of these crosses up to 1929.

The same zebu bull "Ganges" was crossed with his mongrel granddaughter "Tchornaja" (Figure 14) which brought two calves, but unfortunately these latter were short-lived. Finally the zebu bull "Ganges" was crossed with two yak cows (Figure 2) in consequence of which the bull "Samson" was born from one of the cows and the cow "Zagadka" (Figure 9), from the other. The cow "Zagadka" (Figure 9), by a pure-bred hornless yak bull (Figure 2), produced a heifer (Figure 14).

Thus a total of fourteen animals was obtained from the hybridization of the zebu and the yak.

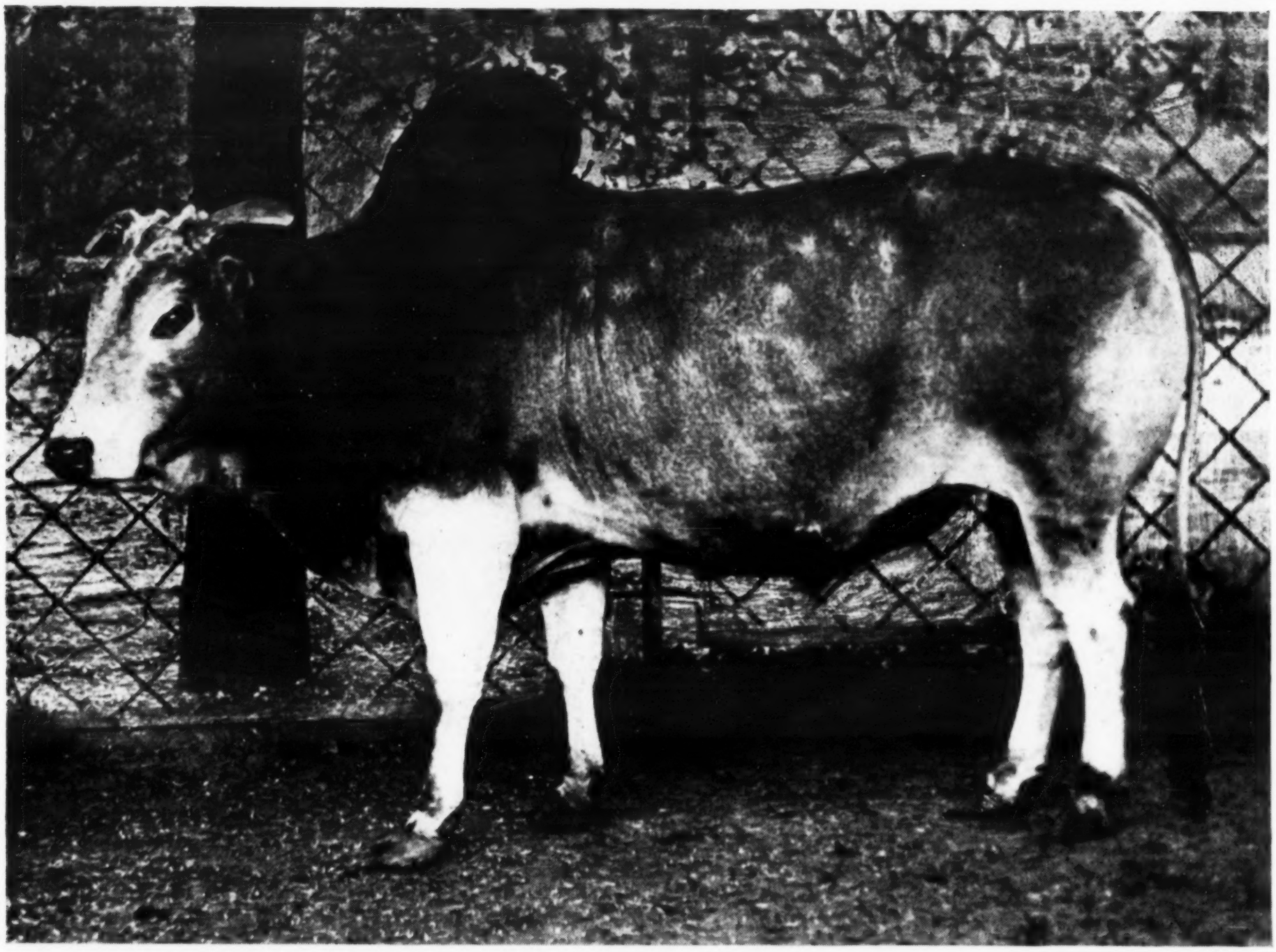
The chart (Figure 15) gives a general conception of the relationships of the family in question.

Fecundity of Female Hybrids and Sterility of Male F_1 and F_2 Hybrids

The most striking fact which comes to one's attention when analyzing the results of the above mentioned intergeneric hybridization is that the female hybrids of both F_1 and F_2 progeny are fully fertile. Three cows have reached sexual maturity ("Paria" and "Zagadka" of the F_1 and "Tchornaja" of the F_2 progeny) and they all have borne calves. They have been fertile when crossed with either the zebu ("Paria and "Tchornaja") or the yak ("Zagadka").

While the female hybrids have always proved fecund, the male hybrids of both the F_1 and F_2 progeny have, on the contrary, proved sterile. The hybrid bull "Samson" (of the F_1 generation), out of a yak cow by a zebu bull, was confined for more than a year with the cow "Zagadka" after her calving. During this period they mated many times but with no sign of impregnation and the rut could be repeatedly observed. When one examines the scrotum of the bull "Samson" from the outside one can easily see that his testicles are considerably less developed than those of the normal zebu or yak bull.

Four of the bulls of the F_2 generation, out of the hybrid cow "Paria" by a zebu bull, have reached sexual maturity at the moment of writing this article ("Rajah," Figure 13; "Son of Ganges," and "Buyan," Frontispiece; and "Malish"—the latter is three years old). They all have a well developed sexual instinct and they all cover the cow "Paria" with which they have been pastured in the same enclosure for the last two years, but she has never become pregnant after mating with these bulls. The scrotum of these bulls is little developed, drawn upwards to a



THE ZEBU SIRE

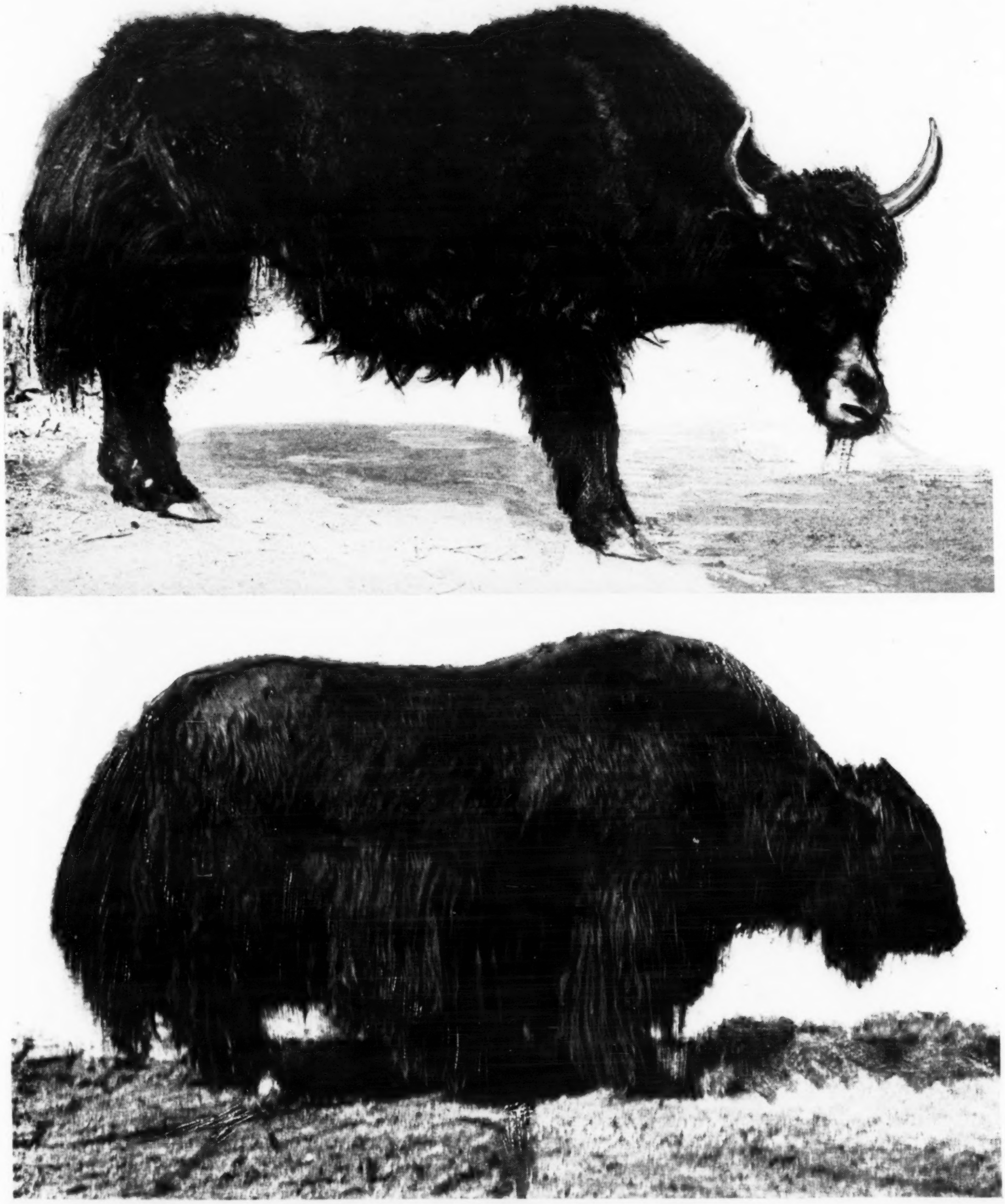
Figure 1

Ganges, a pure-bred zebu bull, was used in these experiments with yak hybrids. The zebus or Brahma cattle are a tropical and sub-tropical species native to India, but today found in many tropical countries. Their resistance to tick fever has been utilized to extend cattle-raising in tick infested regions in the southern United States.

great extent, and their testicles are considerably less developed than those of the normal zebu and yak bulls.

In order to obtain information as to the reasons for the sterility of these bulls, we castrated the oldest of them ("Rajah") in 1927, at the age of four years. Figures 3, 4 and 5 represent the histological construction of the testicle and of the epididymis of this hybrid. On examination of the histological section of the testis stained according to Heidenhain and Mallory, it is easy to discern the strong development of the interstitial tissue and the relatively weak development of the seminal canals the sides of which, as a rule, are composed of one layer of the Sertoli type cells alternating with early spermatogonia. In some canals it is possible to discern cells with a degenerating nucleus, pushed to the region of the canal. These cells belong to the spermatogonium type and even possibly to that of early spermatocytes, but such cells are few in number and they bear obvious signs of degeneration. The section through the epididymis gives evidence of a complete absence of mature germ cells.

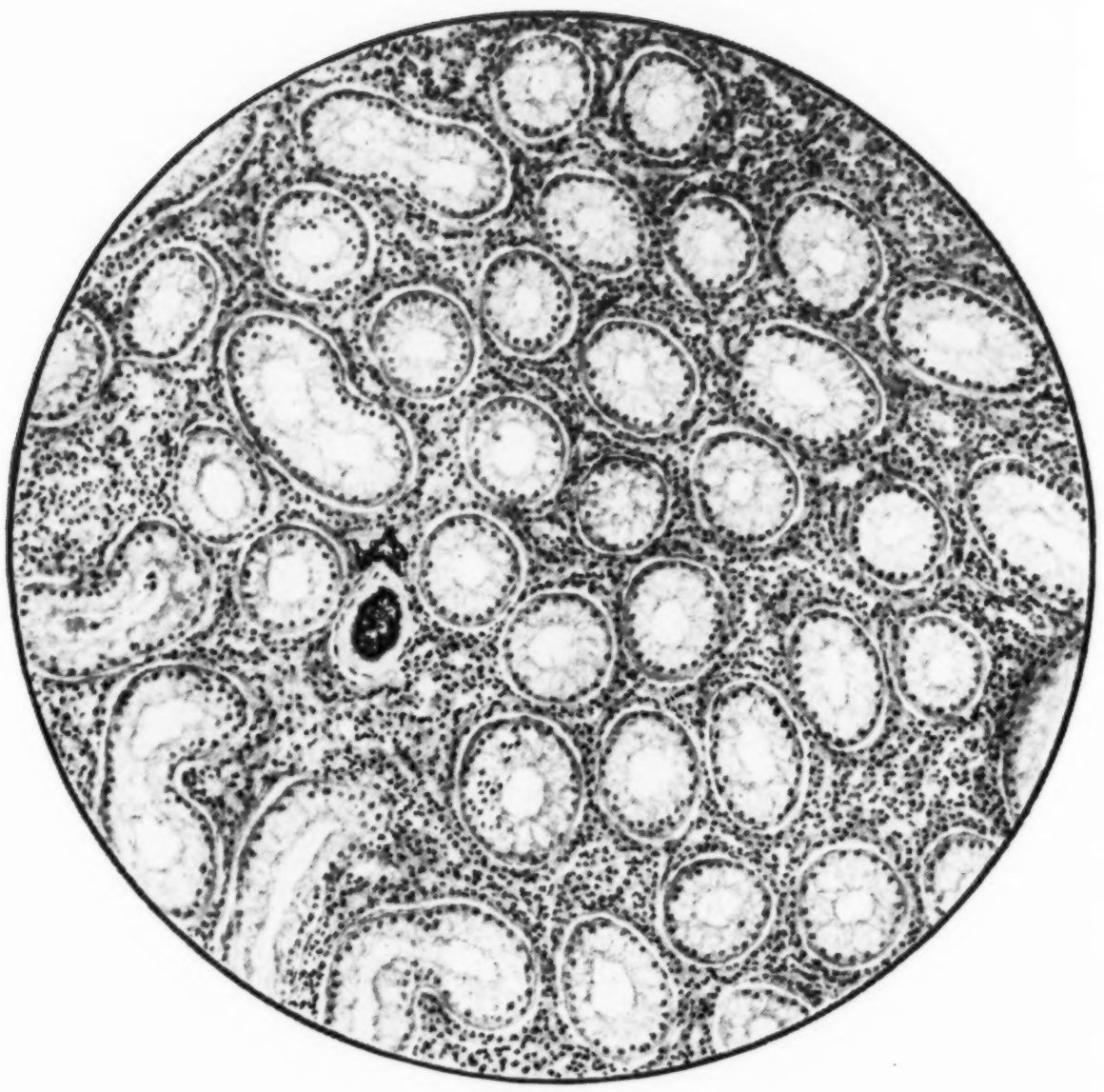
In short, the histological investigation of the testicle of one of the hybrid bulls has shown that their sterility is due to a complete absence of developed generative cells and an almost complete absence of spermatogenesis. It is worthy of note that in spite of the absence of mature spermatozoids and the presence of only Sertoli type



MALE AND FEMALE YAKS—CATTLE OF THE ARCTIC

Figure 2

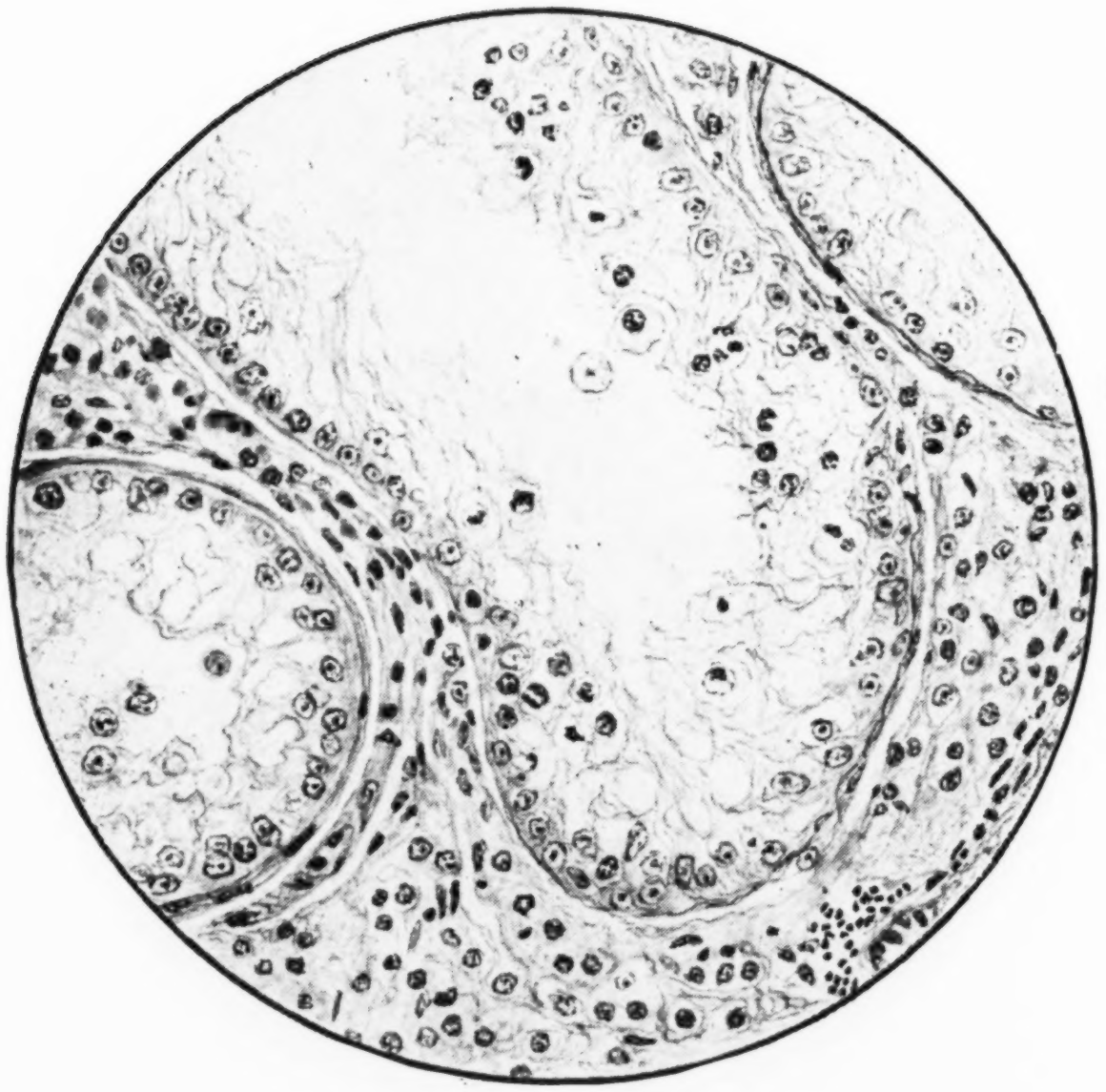
A pure-bred yak cow (above), and "Komsley," a hornless yak bull used in the experiment with zebu crosses. The long fringe is characteristic of the yak. Only a trace of this appears in the hybrids.



DEVELOPMENT RETARDED

Figure 3

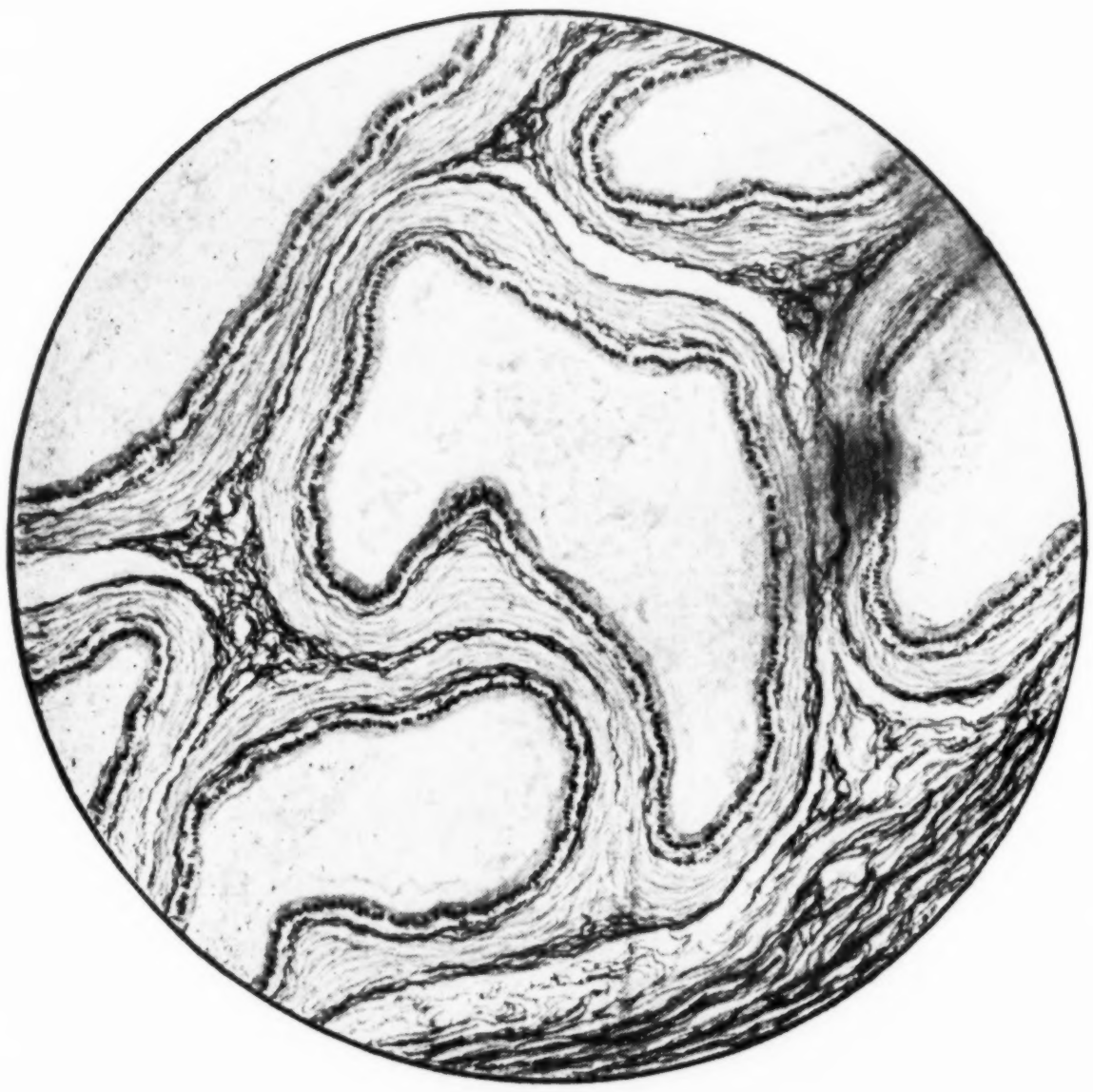
Section through the testicle of the bull "Rajah"—F_1—4½ years old. The seminal canals are devoid of spermatogenesis. The interstitial tissue is comparatively well developed. (Stained Heidenhain. Zeiss. Ob. A, Oc. 5x).



EARLY STAGES NORMAL

Figure 4

Section through the testicle of the same bull as on figure 3. One of the few seminal canals is visible with early stages of spermatogenesis. (Zeiss. Ob. D. Oc. 5x).



STERILITY DUE TO ABSENCE OF GERM CELLS

Figure 5

Section through the epididymis of the same bull. Spermatozoa are absent in the canals.

cells and spermatogonia in the seminal canals, the sexual instinct and other secondary sexual characters of the males are well developed.

Heterosis

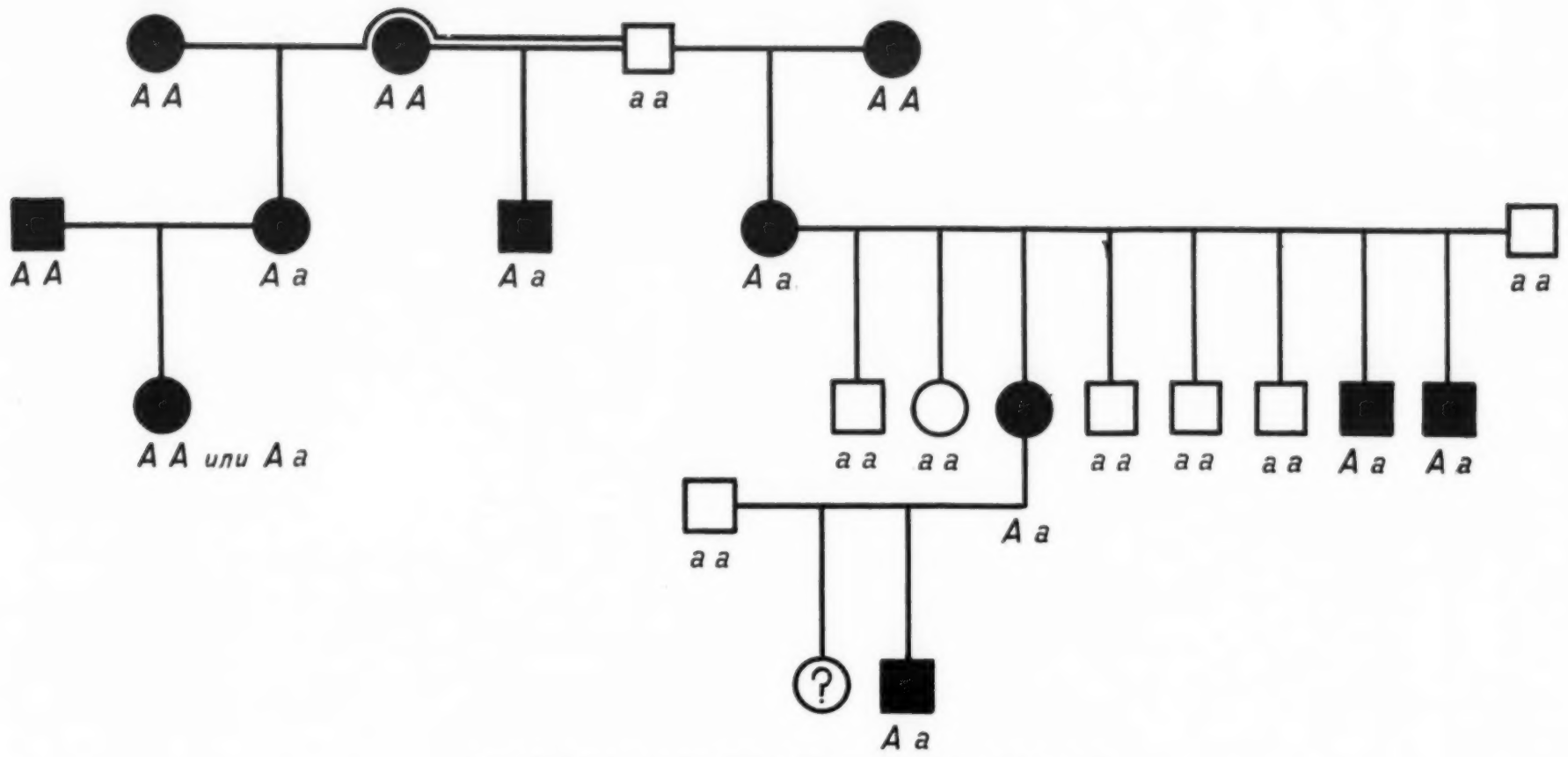
In the literature it has been pointed out more than once that as a result of the crossing of individuals of different species the size of the body of the hybrids of the first generation considerably exceeds that of the original pure bred species. We ourselves had the opportunity of observing this phenomenon on material of the Zoological Gardens "Ascania Nova," when crossing the ure with the bison, the ure with cattle, and bison with cattle.

The increase in size of the body in hybrids is called *heterosis*. In our zebu-yak hybrids we can clearly observe the phenomenon of heterosis in sterile bulls of the F_1 progeny and less clearly in females of the same progeny. The F_1 bull "Samson" reached a size considerably exceeding that of either zebu or yak bulls.

Material on the Genetics of the Inter-Species Zebu-Yak Hybrids

The fertility of the female hybrids enabled us to gather material as to the inheritance of certain characters as a result of this hybridization. We took into consideration the following characters: 1. Coat Color, 2. Length of Hair, 3. Fringe, 4. Length of Tail Hair, 5. Shape of Hump, 6. Shape of Horns, 7. Shape of Muzzle. In analyzing our material we came to the conclusion that even in the case of our intergeneric crossing there is clear evidence of mendelian segregation. Some characters, as for instance, the shape of the horns, are probably determined by multiple genes, but as yet it is rather difficult to explain exactly this complex of genes owing to lack of material.

This lack of material hampers us in drawing conclusions with regard to all the above mentioned pairs of characters, but we believe that, nevertheless, our material will allow us to come to a series of quite obvious conclusions and will be of some use to those who would care to continue this work. I shall give below all the material as to



INHERITANCE OF COAT COLOR

Figure 6

Inheritance scheme of coat-color in the mating of a grey zebu (*aa*) to a black-brown yak (*AA*). Results of mating enable us to presume that the black-brown color is dominant (*A*) and the grey color recessive (*a*).

the inheritance of the above mentioned six pairs of characters.

Coat Color

From the crossing of the gray zebu with the black-brown yak cows there resulted three individuals in the first generation—all of them of the black-brown color. At the further crossing of the black-brown cow of the F_1 generation ("Paria") with the gray zebu bull ("Ganges") three individuals out of eight were black-brown and five gray (chart, Figure 6). The crossing of the black-brown cow of the F_2 generation ("Tchornaja") with a gray zebu bull resulted in the birth of a black-brown cow and a black bull. The crossing of the black-brown cow from the F_1 generation ("Zagadka") with the black-brown yak bull resulted in the birth of the black-brown cow "Komolaja." Analyzing the color of the black-brown individuals of the F_1 and F_2 generations we find in all of them the characteristic gray stripe on the back.

All the above mentioned material is by no means opposed to the supposition that the black-brown color is dominant over the gray (see Figure 6). From the theoretical point of view, however, it is possible to admit a different and at first sight contrary interpretation of facts. One can admit that the gray color is dominant when the crossed zebu bull ("Ganges") is heterozygous as to color (*Aa*), where *A* is the gene of the gray color and *a* —that of the black-brown color (see Figure 6). The wide range of color in the zebu makes this supposition probable. A more precise analysis shows, however, that the second supposition should be dropped.

Here the fact is characteristic that the individuals from the F_2 generation ("Bujan," "Malish" and others) that were black-brown at maturity, almost at the moment of birth and during the whole time up to the time they shed their first coat of hair were of gray-brown color. Only after the first year did they become black-brown. This could never have been the case if the black-brown color were the sign of the homozygous recessive form.

All this enables us to affirm that the black-brown color of the yak is dominant (*A*), while the gray color of the zebu is recessive (*a*).

It is worth mentioning that the gray

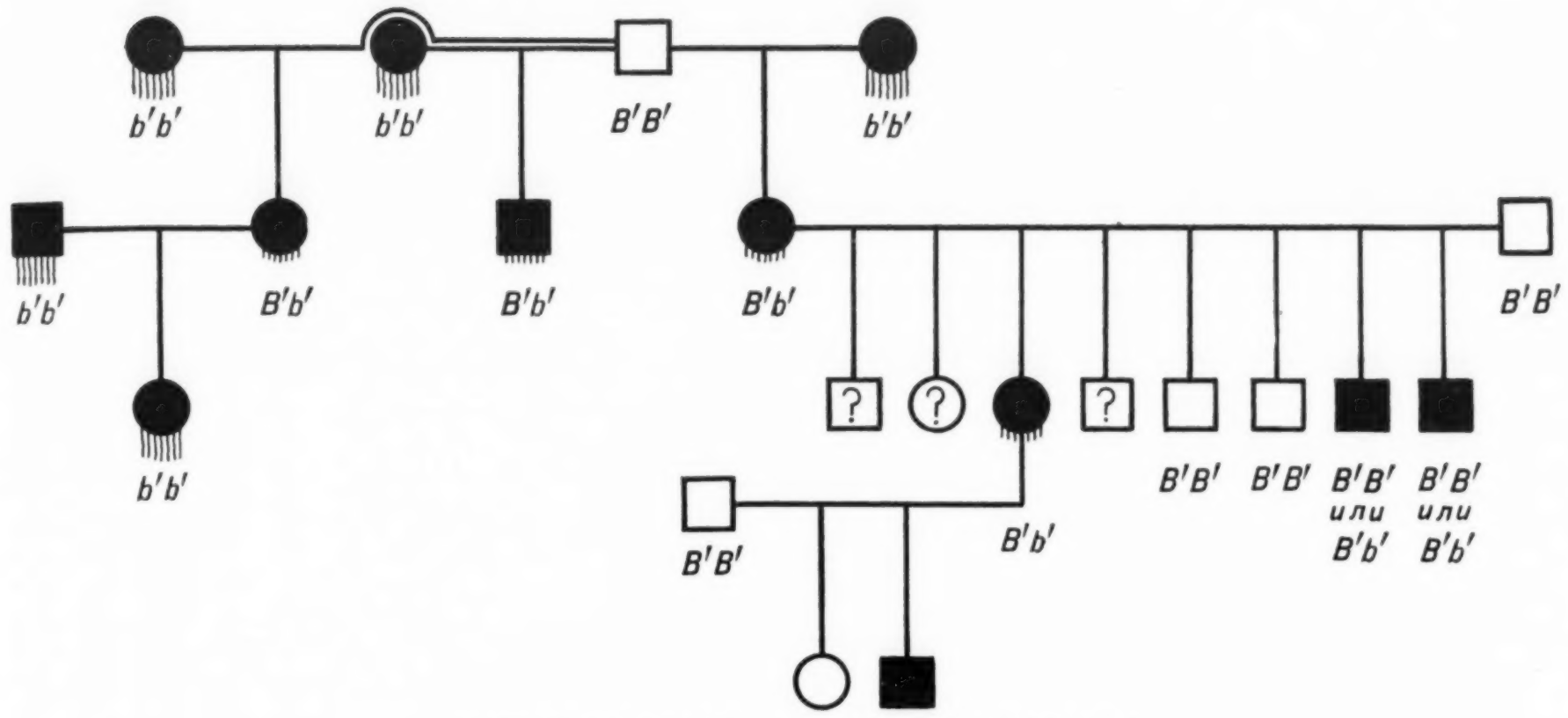


Figure 7

Inheritance scheme of hair length in the mating of a short-haired zebu bull (*BB*) to long-haired yak cows (*bb*). Results of matings enable us to presume that the length of the hair is determined by two couples of allelomorphic genes, the heterozygous state (*Bb*) leading to the development of a character of an intermediate type.

color of the individuals of the F_2 progeny is not quite uniform: "Son of Ganges," for instance, is a great deal darker than his elder brother "Rajah."

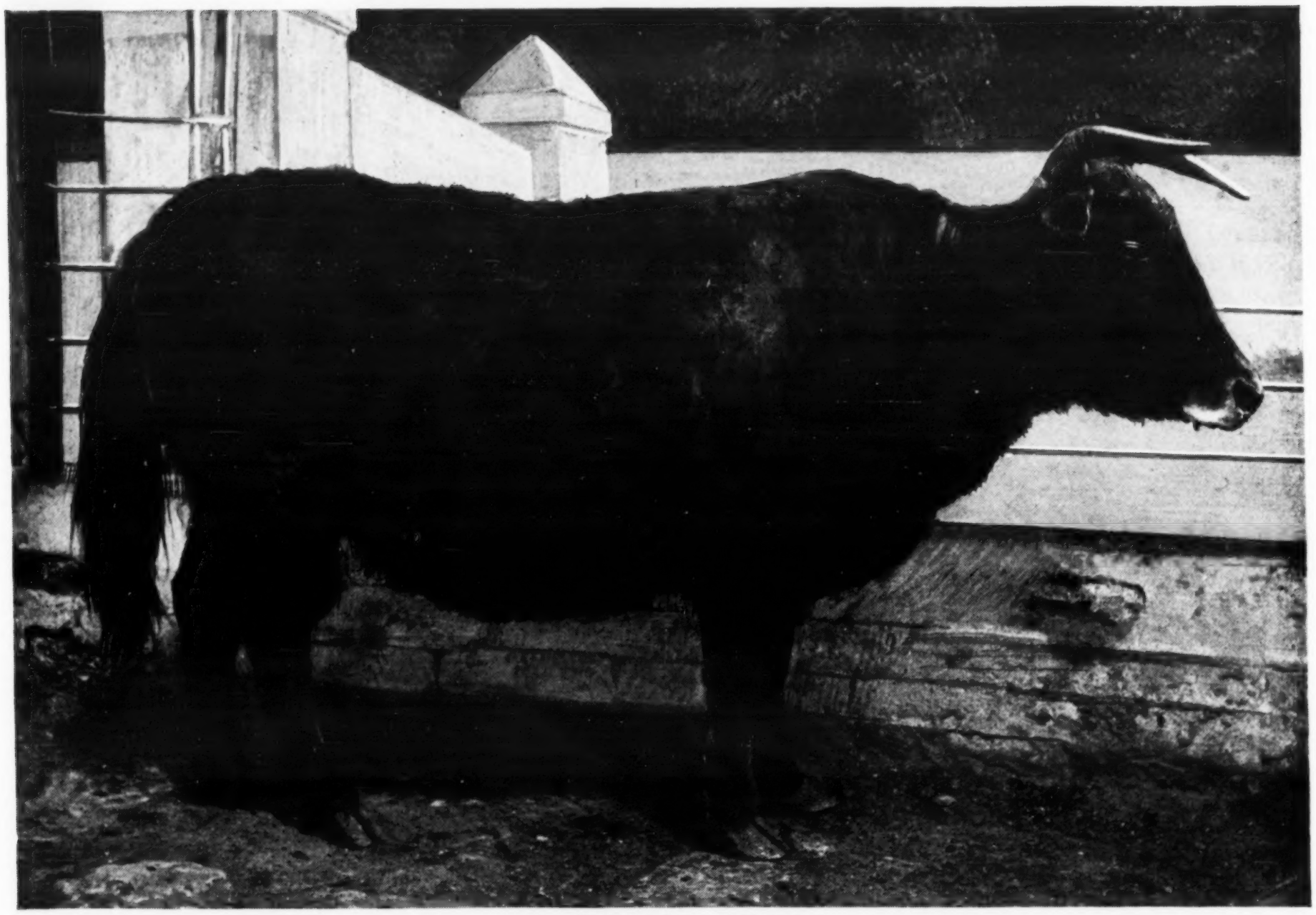
Length of Hair

When the short-haired zebu and the long-haired yak were crossed, the hybrids of the first generation, three of them ("Paria," "Zagadka" and "Samson") had relatively short hair. In summer it only a little exceeded the length of the hair of the zebu, but in winter the hair of the F_1 generation reached a length which considerably surpassed the length of the hair of the zebu (see Figures 8 and 9). The length of the hair of the cow "Paria" has somewhat increased with age. Just where the sides join the belly, a slanting stripe of longer hair corresponding, to the place of growth of a yak's fringe can be observed.

The progeny resulting from the crossing of a cow of the F_1 generation with a pure-blood zebu bull has a hair cover of the zebu type and but little surpasses it in length (see Figure 7). The above mentioned material enables us to speak either of an incomplete dominance of the short-haired zebu over the long-haired yak type or, to be more exact, of an intermediate type of character in the F_1 generation.

Fringe

The body of the yak is not only covered with longer hair than that of the zebu, but there where the sides join the belly there grows hair of such a considerable length that it forms a hair fringe on both sides of the body, falling in waves and mingling on the back with the hair of the tail. This fringe gives the impression that the yak is wearing a skirt of long hair. The line of growth of the hair fringe and its shape is shown in Figure 10. We consider it impossible to analyze the inheritance of such a typical character as "the fringe" independent of the general character of "the length and the thickness of the hair." From the crossing of a yak cow having a luxurious fringe with a zebu bull having no fringe at all there resulted three individuals (two cows and a bull) in the first generation. All the individuals of the F_1 progeny have no fringe, but on that line where the yak has the fringe hair, where the sides join the belly, the F_1 hybrids have a ridge of



A HYBRID COW

Figure 8

"Paria," an F_1 of the cross of a yak cow with a zebu bull, was fourteen years when photographed. She is a mixture of zebu and of yak characteristics, some from each parent being present, and in some she is intermediate.

longer hair growing in two opposite directions; the hair on their belly is no longer than that of the zebu. In short, in the F_1 hybrids we find only a slight hint of fringe. To give a general form to our idea we find it necessary to say that the type of hair cover without the fringe may be called dominant, but dominant incompletely.

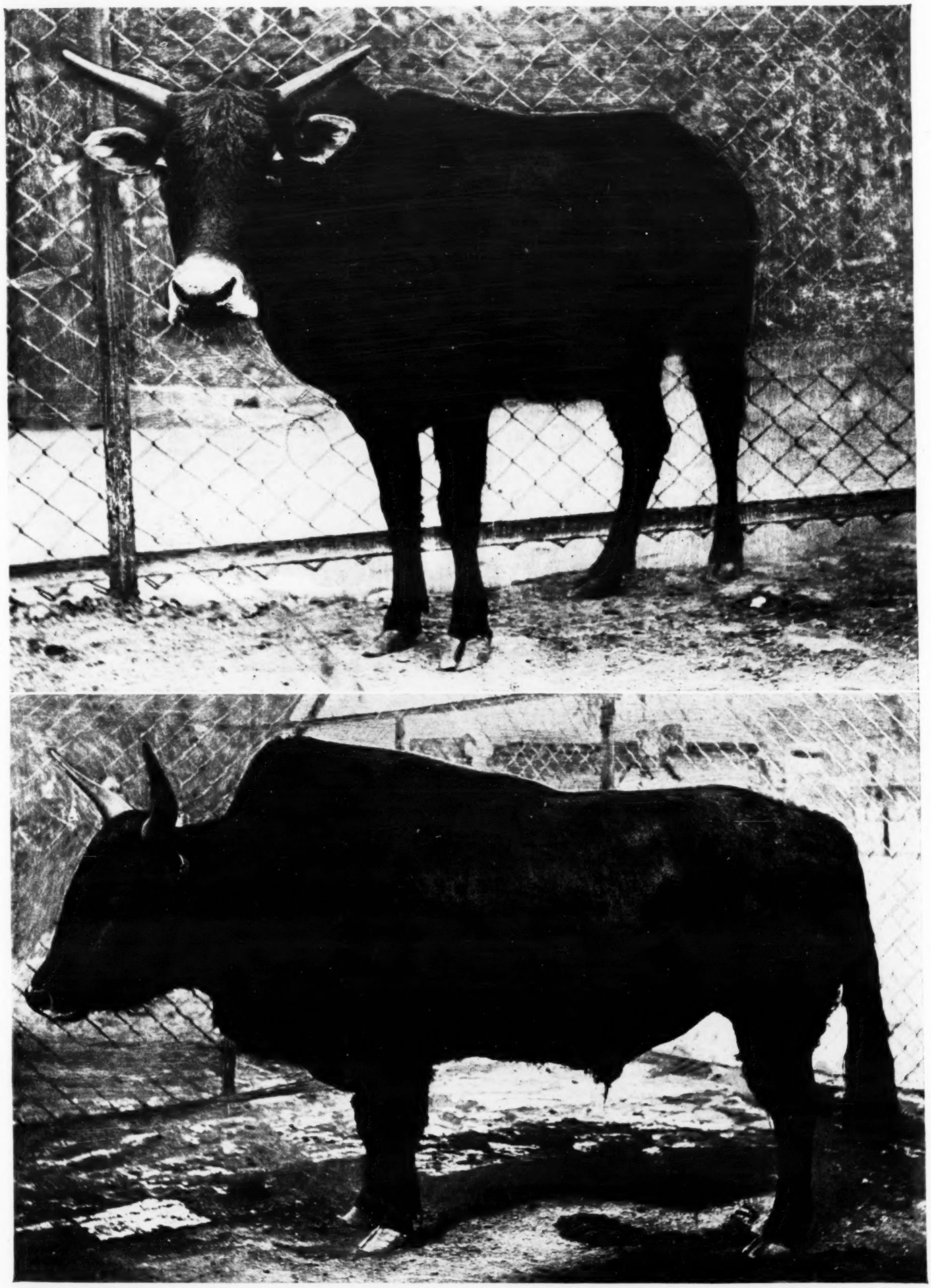
In the F_2 progeny of the F_1 cow "Paria," heterozygous as to the character in question (*Bb*), crossed with a pure-blood zebu with no fringe (homozygous for the dominating genes *BB*) five individuals were studied: three of them were completely without fringe (*BB*) and two had only a hint of fringe (*Bb*). The crossing of the cow "Zagadka" of the F_1 generation (*Bb*) with a pure-blood yak bull (*bb*) resulted in 1929 in a heifer which, as may be expected, already in the spring of 1930 has developed a splendid fringe (*bb*).

Length of Tail Hair

The zebu's tail is covered with short hair all along except at the end where the hair is considerably longer and forms a tassel; the zebu's tail is approximately of the same type as that of our cattle.

The yak's tail is covered with long hair all along, somewhat reminding us of the long-haired tail of the horse.

The crossing of the zebu "Ganges" with three yak cows gives us progeny consisting of three units: two cows, "Paria" and "Zagadka," and a bull, "Samson." All the individuals of the first generation have the tail well covered with hair all along. One should, however, bear in mind that though the length of the tail hair of the F_1 hybrids is like that of the yak, they are not completely identical. The hair of the F_1 hybrids is still shorter than that of the pure-blood yak. We have every reason to speak of the incomplete

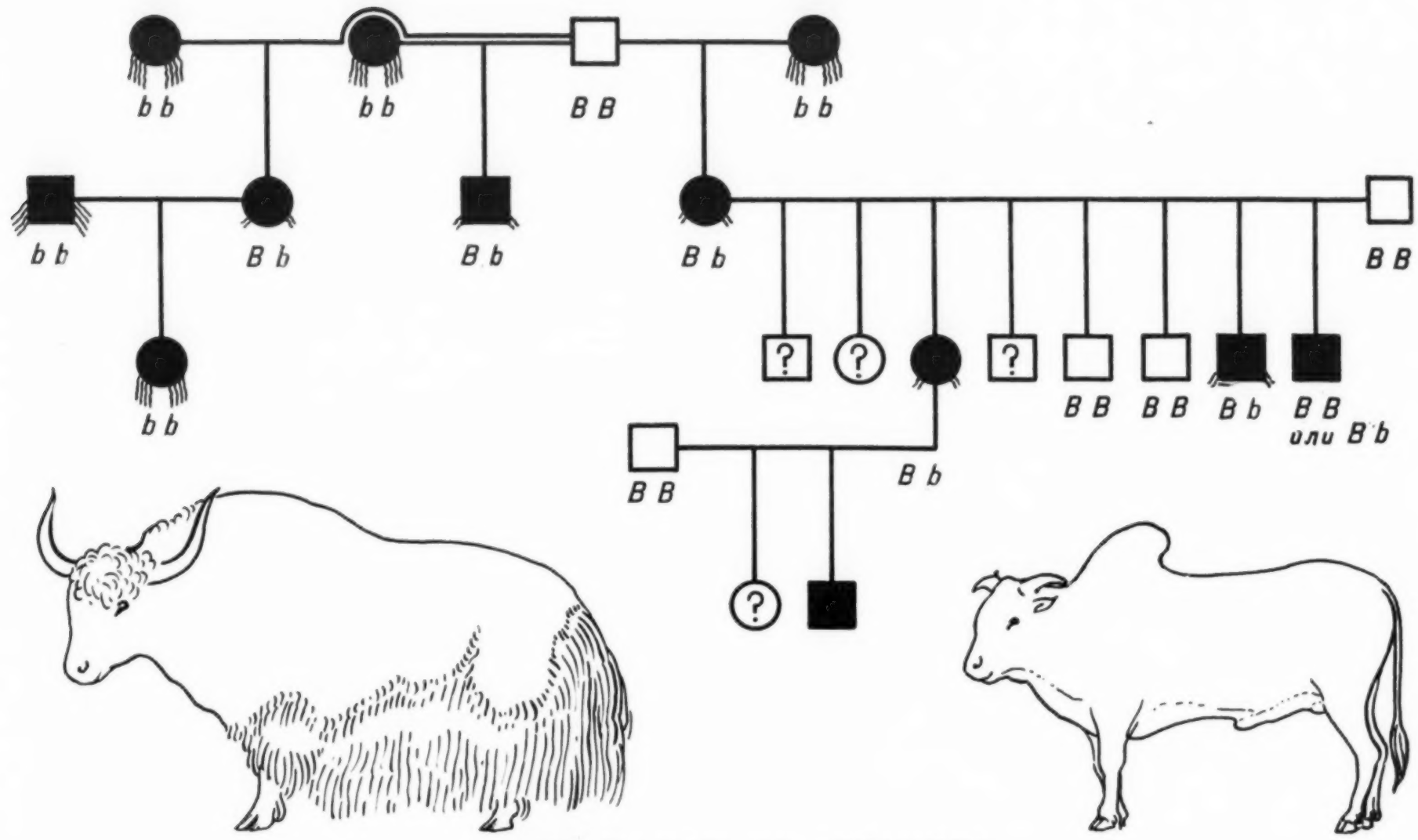


FIRST GENERATION HYBRIDS

Figure 9

Above—"Zagadka," an F_1 hybrid cow, about four years old.

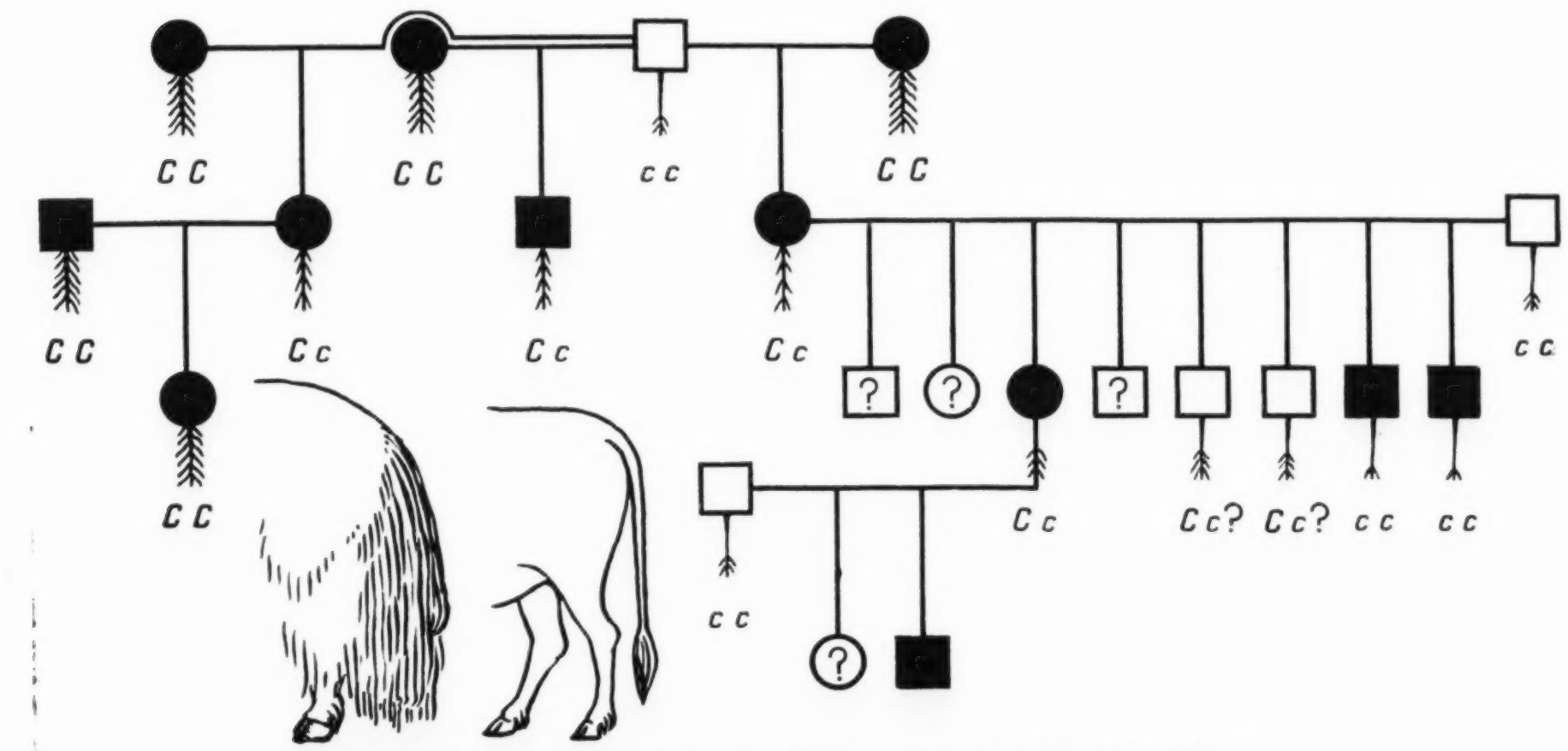
Below—"Samson," an F_1 bull, about four years old. In both instances the sire was a zebu and the dam a yak (Figures 1 and 2).



INHERITANCE OF "FRINGE"

Figure 10

Inheritance scheme of "fringe" in the mating of a "fringeless" zebu (*BB*) to yak cows with "fringe" (*bb*). Evidently the absence of fringe (*B*) is dominant (but not completely) over fringe development. The heterozygous state (*Bb*) is characteristized by a slight lengthening of hair along the limit of the abdomen and side and on the abdomen.



INHERITANCE OF LENGTH OF HAIR ON TAIL

Figure 11

Inheritance scheme of the length of the hair on the tail. Result of the mating of a yak with a long-haired tail to a zebu with only a long-haired tassel on the tail. The data are insufficient to state the whole number of genes determining the hair length of the tail. We have reason, however, to suppose that the hair length of the tail is affected not only by a special gene, but also by those determining the hair length of the body in general.

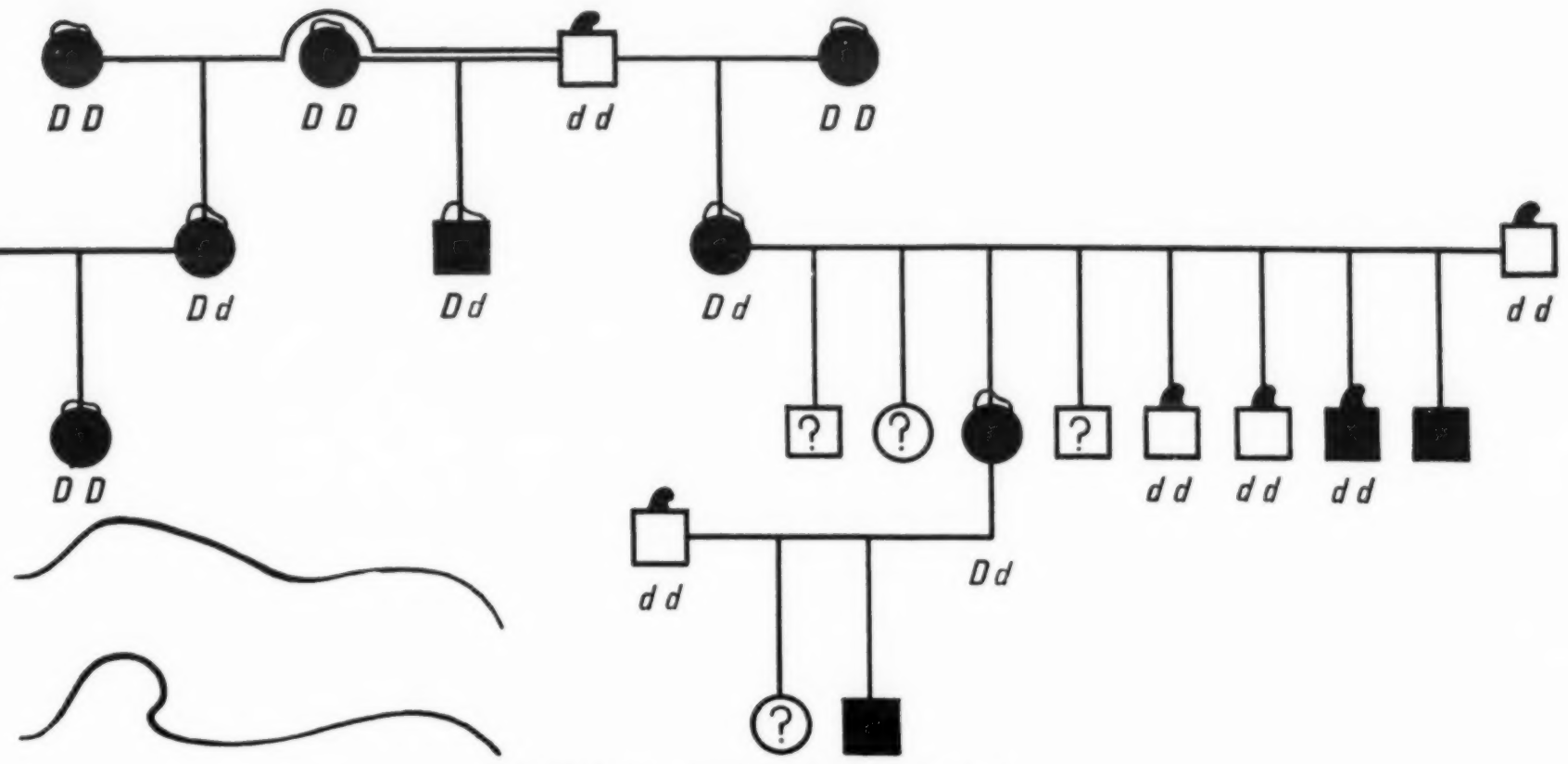


Figure 12

Inheritance scheme of the hump of zebu and yak types. There are reasons to suppose that the hump of the yak type is dominant.

dominance of the yak type in the tail.

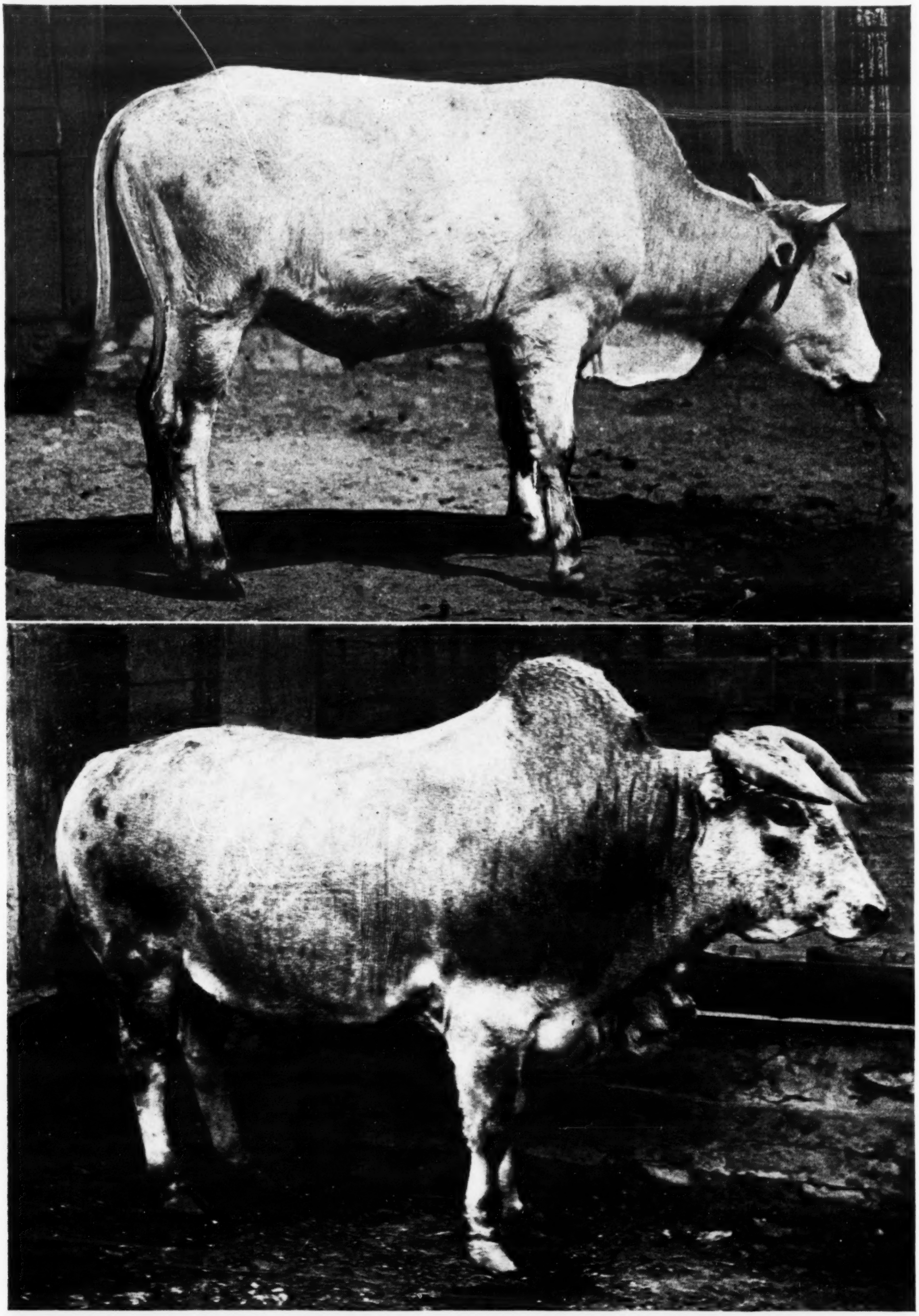
When crossing the zebu with the hybrid cow "Paria" we were able to study five individuals from the whole number of eight. Two of them—"Buyan" and "Malish"—had the tail of the zebu type with a tassel at the end; but this tassel was thinner than that of the pure-bred zebu; three others ("Tchornaja," "Rajah" and "Son of Ganges") had tails the length of hair of which reminded one of that of the zebu, but the tassel was much thicker than that of the zebu. The long hair of the tassel began almost at the middle of the whole length of the tail.

The length of the tail hair of these three individuals represents some intermediate form between the length of the hair of the zebu and that of "Paria" (a hybrid of the F_1 generation). If we assume that the length and the thickness of the tail hair is determined by one gene and denote the zebu type of the tail hair by *c* and that of the yak type by *C*, we have *Cc* in the first generation (a tail of the "Paria" type).

When crossing "Paria" (*Cc*) with the zebu (*cc*) we should have in their progeny 1*CC* and 1 *cc*, i.e., one half of the progeny should have tails of the zebu type, the other half—of the "Paria" type; in reality, however, there is no "Paria" type of tail in the F_2 generation, but they all have tails of some intermediate type. The result can be understood either as evidence of the fact that Mendel's law cannot be applied to intergeneric crossing or we should look for the causes of this phenomenon in the fact that the length of the tail hair is determined not by one, but by a greater number of genes. I consider the second interpretation more sound. I think that the length of the hair at the root and at the upper part of the tail is determined by the gene on which depends the length of the hair of all the body (*Bb*) and the growth of the tassel depends on the genes *Cc*. If we accept this point of view, the length of the tail hair will vary and will depend on the combination of genes. In this case we can conclude that:

B^1B^1cc is the tail of the zebu type;
b^1b^1CC is the tail of the yak type;
B^1b^1Cc is the tail of the Paria type;
B^1B^1Cc is the tail of the Rajah type; of the F_2 generation;
B^1b^1cc is the tail of the Buyan type of the F_2 generation;

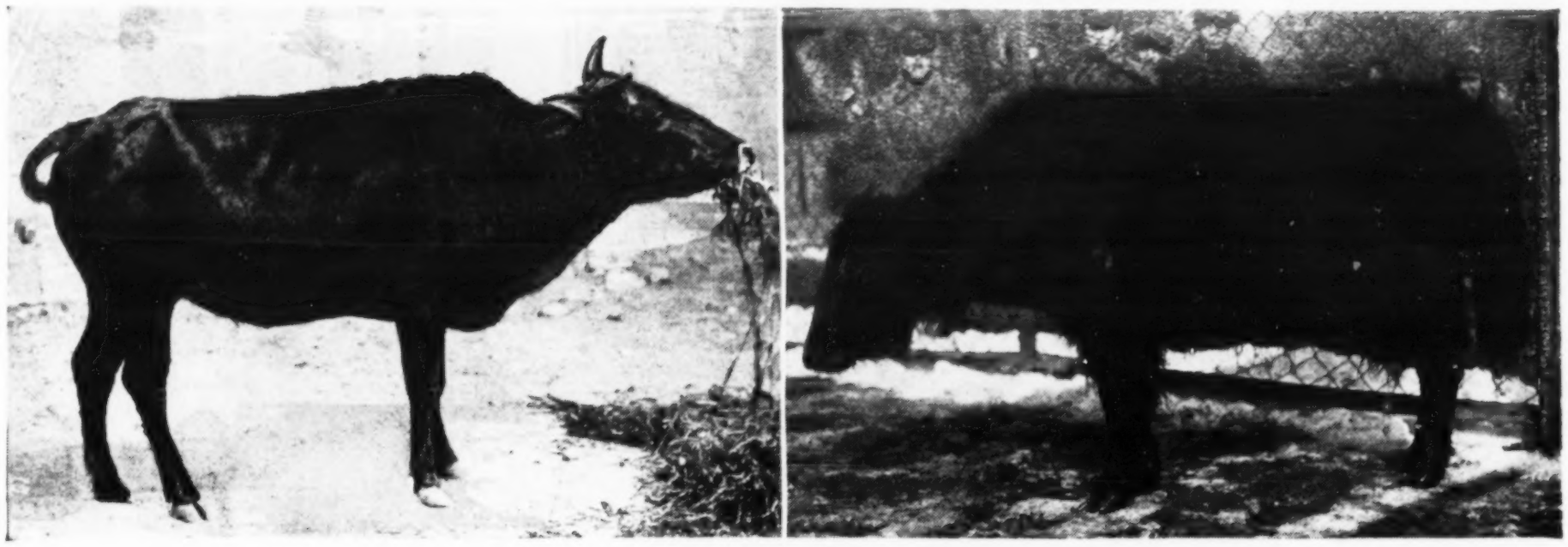
b^1b^1CC, b^1b^1Cc, b^1b^1cc } Such combinations cannot be found in the progeny of "Ganges" and "Paria."



DEVELOPMENT OF THE HUMP WITH AGE

Figure 13

Two photographs of "Rajah," an F_2 backcross bull (dam, "Paria" [Figure 8]; Sire, zebu "Ganges" [Figure 1]). The upper photograph is at 18 months of age; the lower at 6½ years of age. At the earlier age the hump would seem to have disappeared in the hybrid, while later the yak type appears to be partially dominant.



BACKCROSSES TO THE PARENT SPECIES

Figure 14

At the left, a hybrid heifer ("Tchornaja") eighteen months old. Her dam is the hybrid cow "Paria" (Figure 8); her sire a pure bred zebu bull. At the right is shown the backcross of an F_1 cow ("Zagadka," Figure 9) by a pure bred yak bull.

Hump

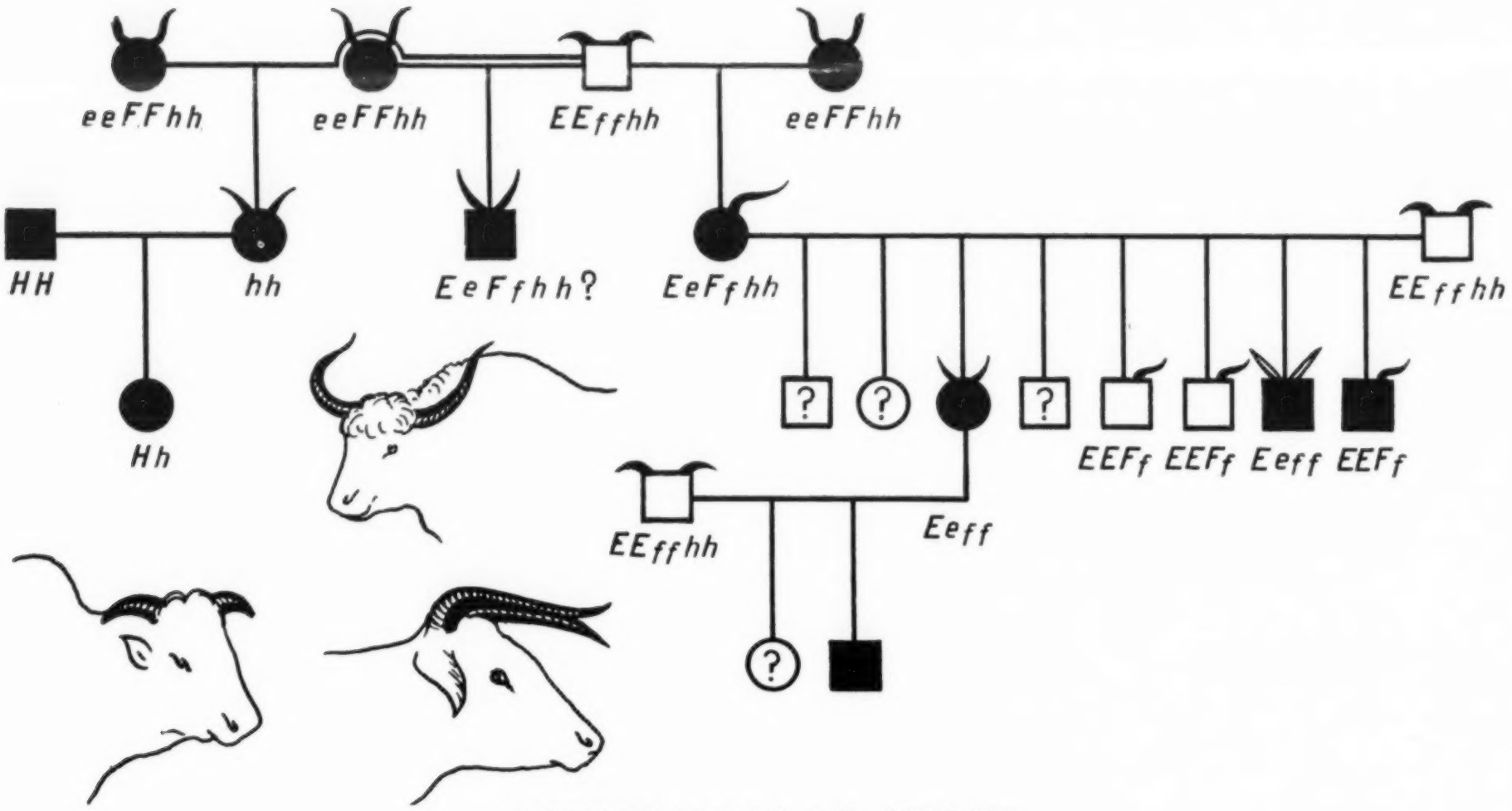
The hump of the yak is characteristically different from that of the zebu. The hump of the yak having its highest point in the fore region of the shoulder slants gradually towards the middle of the back (towards the back from the highest point the hump forms a bow the convexity of which is turned upwards (Figure 12); the hump of the zebu, situated in the fore region of the shoulder, somewhat backwards from its highest point, falls sharply in the limits of a few vertebrae in the region of the scapula so that a bow is formed the convexity of which is turned downwards. The hump of a mature zebu even hangs slightly over the back (Figure 12). There is still another difference between the shape of the yak's hump and that of the zebu's hump: the latter has its maximal breadth in the sphere of its maximal height, the former has its maximal breadth in the region behind its maximal height. The hump of the yak is like the breast-bone of a bird and the hump of the zebu reminds us of a lump.

The hump of the yak cow is considerably less developed than that of the yak bull. The dimorphism in the development of the hump of the zebu is not so great.

Our cow "Paria," out of a yak cow by a zebu bull, has hardly any hump (Figure 8) and the line of her back is somewhat like that of the back of the yak cow (the cow "Zagadka" has the back of the same type but the bull "Samson" resulting from a similar crossing has a hump the shape of which is like that of the hump of a yak (see Figure 12).

Our slight material enables us to say that the shape of the lump of a yak dominates over that of the zebu.

When the zebu bull "Ganges" was crossed with the hybrid cow of the F_1 generation ("Paria") we had the possibility of observing four individuals of the F_2 generation (one cow and three bulls). The cow had a hump the shape of which was near to that of the hump of a yak cow, three bulls—("Rajah, 7 years old; "Son of Ganges" of the age of 6 and "Buyan"—5 years old have humps of the zebu type. One of them, "Buyan" has a hump with a sufficiently developed slope, which reminds us a little of the hump of a yak. The bull "Malish" is now three years old; the form of his hump is far from



INHERITANCE OF HORNS

Figure 15

Firtly, by analogy to other representatives of this race and on the basis of a single mating of the F_1 progeny of our pedigree, hornlessness is evidently a dominant character (*H*). Secondly, the shape of the horns of the yak and of the zebu is evidently determined by no less than two pairs of genes. One of these pairs determines the shape of the horns (*Ee*) and the other pair—the intensity of their growth (*Ff*).

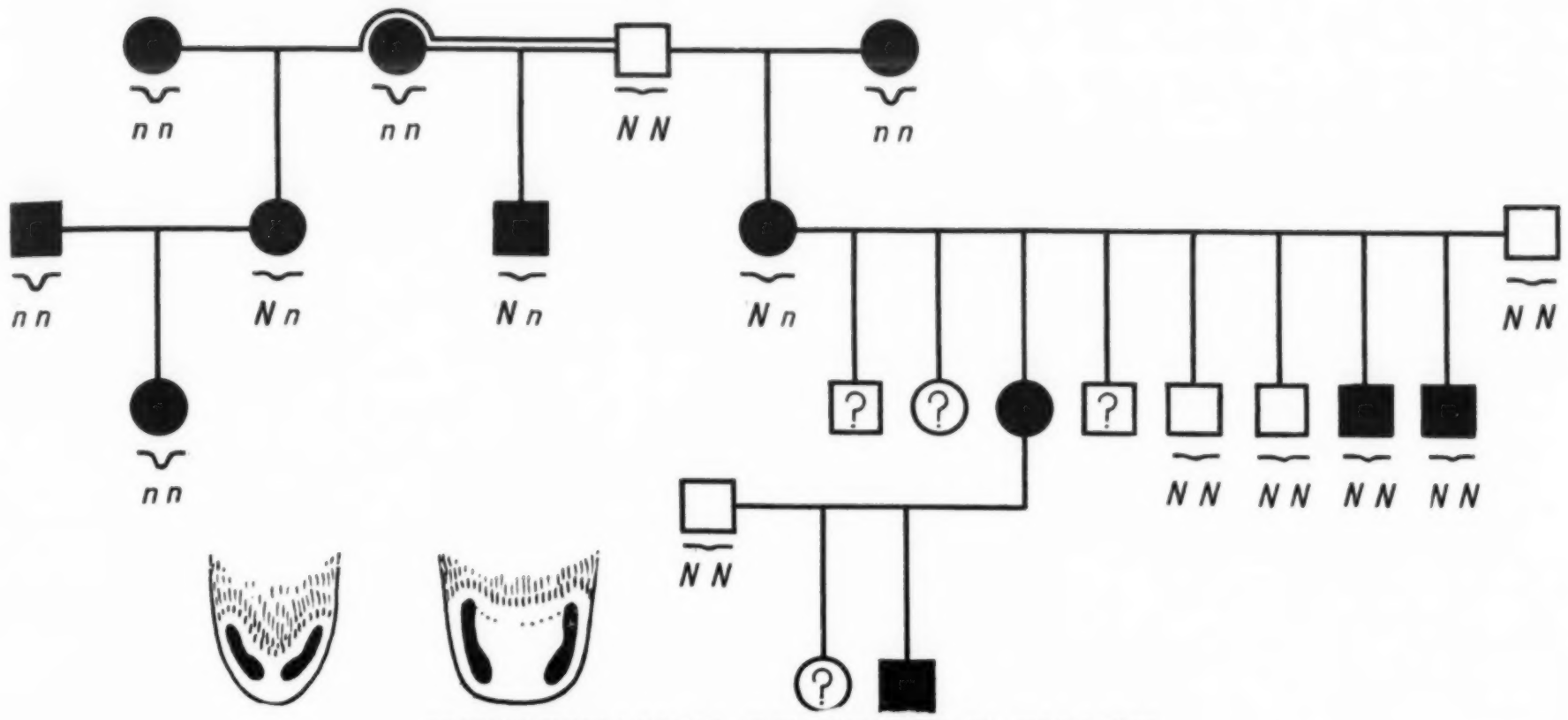
being fixed, but the course of its development is like that of the hump of a zebu. One should point out, however, that the hump of all the bulls of the F_2 generation is not quite identical to that of the zebu. The line of the back slope of the hump in hybrids has a less broken, more slanting form than that of the zebu, and this line somewhat reminds us of the hump of a yak. If we admit that the shape of the hump of the zebu is recessive we shall come to the conclusion that from the five individuals of the F_2 progeny, all the four bulls resulting from the crossing of the zebu bull (*dd*) with the hybrid cow "Paria" (*Dd*) represent the genotype *dd*, and the cow "Tchornaja"—*Dd*. In all probability, some other gene or genes, besides the gene *D* and *d*, affect the determining of the shape of the hump.

Horns

The cow "Paria" of the first generation, resulting from the crossing of a zebu bull, whose horns turn out with the ends inclined somewhat downwards (Figure 1) with a yak cow, whose horns are handsomely curved upwards with the ends turned backwards (Figure 2) has horns pointing forward (Figure 8).

In short, the shape of the horns of the individual from the F_1 generation should be considered as a new formation. When the cow of the F_1 progeny, having horns pointing forward, was crossed with a zebu bull whose horns were turned out, three bulls of the F_2 progeny (Frontispiece and Figure 14) had horns pointing forward and one cow and one bull (Frontispiece) had horns turned upwards and outwards. The cow "Tchornaja" (Figure 14) died at the age of five, when the horns were not yet fully developed. It is, however, possible, that at the sixth or seventh year her horns also would have turned forward.

The results of the crossing show at once that the shape of the horns is determined by more than one pair of genes. Our material has not given us the possibility to define exactly the number of genes most closely connected with the determining of the shape of



INHERITANCE OF MUZZLE SHAPE

Figure 16

Inheritance scheme of the shape and hairiness of the muzzle. The nostrils of the yak are set at an angle, those of the zebu are parallel, and the zebu's muzzle is bald. Shape of zebu's muzzle is incompletely dominant.

the horns, but some observations may be of use for the future. First of all we must point out that those three bulls from the F_2 generation of which it was said that they had horns pointing forward, like those of their hybrid mother—are of a different age and, at present, have horns of a different shape. The oldest bull ("Rajah" of seven years) has horns pointing forward, the second of them as to age ("Son of Ganges" of six) has his horns directed outwards but their ends are already beginning to turn forward; the youngest of them ("Malish"—three years old) has horns turned outwards, but their shape fully corresponds to that of the horns of "Rajah" and "Son of Ganges" which fact enables us to expect the same final form.

Observation of horns of this type has shown that during the first years of development these horns are very like those of the pure bred zebu "Ganges." If "Rajah" of the F_2 generation had been described before his sixth year, his horns would have been considered those of a pure bred zebu. The principal difference in the growth of the horns of "Rajah" and his brothers from that of the horns of the zebu "Ganges" is that the horns of "Rajah" and his brothers grow quicker than those of the zebu, and during their growth the rotation round the axis was completed.

Whereas the growth of the horns of the zebu stops, the growth of the horns of its hybrid progeny continues and after the sixth year a sharp rotating turn, which directs the horns forward, is completed. This gives one the impression that the horns of the zebu differ from those of the yak in growth and from those of the hybrid daughter of the F_1 generation—in tempo and, possibly, in the continuity of growth.

It is quite probable that the hybrid of the F_1 generation receives the dominant gene of the form of horn growth (E) from the zebu and the dominant gene of the tempo of horn growth from another allelomorph (F), from the yak.

Muzzle

The muzzle of the yak differs in its character from that of the zebu. The nostrils of the yak are situated at an angle and this angle opens upwards. The nostrils of a zebu are parallel to each other and only in the lower part are somewhat closer. The nostrils of the zebu cover the almost square area of the muzzle. The zebu's muzzle has a bald hairless surface, considerably greater than that of the yak. The upper line of the hair cover is almost

horizontal and is on a level with the upper half of the nostril. The yak's hair grows so low between the nostrils that it seems, that the nostrils are surrounded by a hairless ring, and the space between the nostrils up to the upper lip is covered with hair (see Figure 16).

The muzzles of the cows "Paria" and "Zagadka" and that of the bull "Samson" of the F_1 progeny are of an intermediate type between those of the zebu and the yak. The shape is like that of the muzzle of the zebu. The hair grows low between the nostrils, but not at all so low as that of the yak. One may even speak of the dominance (incomplete) of the muzzle of the zebu. Four individuals of the F_2 generation ("Rajah," "Son of Ganges," "Buyan" and "Malish") have muzzles which in their type are near that of the zebu, and only one cow "Tchornaja" has the muzzle of "Paria" type.

From the above discussion one has every reason to conclude, that the shape of the muzzle of the zebu is incompletely dominant over the shape of the muzzle of the yak.

It is highly interesting to point out the fact, that when the heterozygous cow of the F_1 generation ("Zagadka") with a muzzle similar to that of the zebu, was crossed with a pure bred hornless yak, there resulted the daughter "Komolaia" with the typical recessive muzzle of the yak.

Body Proportions

The body proportions are of a character the forms of which are evidently affected by many genes. Having but little material at our disposal, we can only give an outline of the general impression of the body proportions which catches our eye.

Whereas the zebu's body, short in form, is roundish and set on slim legs, the form of the yak's more bony body is longer, the legs more roughly shaped.

The hybrids of the first generation, as to general configuration of body and constitution—with regard to the length of the body relative to the length of legs, are nearer to the yak than to the zebu. It is interesting to state that in the F_2 generation, resulting from the crossing of the hybrid cow "Paria" with the bull "Ganges"—three bulls out of a total of four (Frontispiece and Fig. 13) have the characteristic proportions of the zebu, and one bull "Buyan," see Frontispiece) has a long body and his proportions are near to those of the yak.

We deem it necessary to point out this feature in the progeny of the zebu-yak hybrids, in order to emphasize that even in such a complicated characteristic as "the general proportions of the body" we can note obvious signs of segregation.

Conclusions

The cross between the zebu and the yak, which has been carried out in the Moscow Zoological Park, enables us to come to the following principal conclusions:

1. The male hybrids of the F_1 and F_2 progeny are sterile.
2. The infecundity of the male hybrids is due to the fact that their testicles produce no spermatozoa.
3. The histological study of the testicles shows that the seminal canals, while having a well developed interstitial tissue, have at the same time only the cells of Sertoli type and spermatogonia. There is no spermatogenesis at all, only its earliest phases can be discovered in some canals.
4. Despite the absence of spermatogenesis, the males have the secondary sexual characters and the sexual instinct fully developed.
5. The female hybrids of the F_1 and F_2 progeny are fecund when crossed with either the zebu or the yak.
6. The phenomenon of heterosis may be observed in the F_1 generation (the hybrids are bigger than their pure bred parents).
7. In spite of the remoteness of the zebu and the yak in the taxonomic system (*Bos indicus* and *Pheophagus grunniens*—i. e., different genera) mendelian segregation takes place in their progeny.
8. The segregation can be observed in the following pairs of characteristics:

1—Coat color; 2—Length of hair of body; 3—Fringe; 4—Length of tail hair; 5—Shape of hump; 6—Shape of horns; 7—Shape of muzzle; 8—General body proportions.

9. As to coat color we can state that the black-brown tint of the yak (A) is dominant over the grey color of the zebu (a).

10. As to the length of the hair of the body, we can speak of an incomplete dominance of the short-haired zebu (B) over the long-haired yak (b), or to be more exact, of a middle type of inheritance.

11. The absence of fringe is dominant (B). The fringe is a recessive character (b).

12. The tail of the yak type (C) covered with long hair all along, is dominant over the zebu type of the tail (c) with a tassel at the end.

The length and the thickness of the tail hair in general is probably determined by no less than two pairs of genes (Cc and B^1b^1); one of them affects the development of the tassel of the tail (Cc) and the other affects the length of the hair of the body in general (B^1b^1).

13. The shape of the hump of the yak (D) is evidently dominant over that of the zebu (d).

14. The shape of the horns of the yak and the zebu is evidently determined by no less than two pairs of genes. As a result of the crossing of a yak and a zebu a new formation in the shape of horns takes places in the first generation.

15. When a zebu and a yak are crossed, the hybrids of the F_1 generation have an intermediate shape of muzzle, whose type is nearer to that of the muzzle of the zebu, with obvious segregation in the F_2 generation.

16. Hornlessness is the dominating characteristic when a horned zebu and a hornless yak are crossed.

17. The long bony form of the body of the yak is dominant over the big square form of the body of the zebu. In the second generation some signs of segregation may be observed.

THE FIRST PLANT PATENT

ON August 18, 1931, the United States Patent Office issued the first patent to the "inventor" of a new variety of plant, under the amendment of the patent laws signed by President Hoover on May 23, 1930.

Curiously and ironically enough, Plant Patent 1 does not go to a plant breeder at all. Mr. Henry F. Bosenberg of New Brunswick, New Jersey, who has the honor of being granted the first patent on "new and useful improvements in an asexually reproduced plant," is a landscape gardener who bought a number of Van Fleet roses for use in his work. One of these proved to be a bud sport, apparently, and a new variety had been—"invented!" The new rose is exactly the same as the well-known climbing rose originated by Dr. Walter Van Fleet, and bearing his name, except that it is claimed to be everblooming.

The Plant Patent granted to Mr. Bosenberg is reproduced in Figures 17 and 18. From a number of points of view this first patent raises interesting problems. We learn from the *Journal of the Patent Office Society* that Mr. Bosenberg avers under oath that he did nothing to originate the new form; the aberrant plant was one of a number he bought for use in landscape work. The plant showed ever-blooming habits, and buds from it perpetuated the tendency. It was tested four years and found not to revert. Nevertheless in the patent specification (Figure 18, line 20) he says: "—but the same ever-blooming habits may be attained by breeding this new quality into other varieties of climbing roses." Obviously nothing appears in the record to substantiate this claim. If the plant is a bud mutation, as seems certain, the quality might be "breedable;" more likely it would not. Perhaps there is nothing serious in permitting such un-

Aug. 18, 1931. H. F. BOSENBERG Plant Pat. 1

CLIMBING OR TRAILING ROSE

Filed Aug. 6, 1930

Fig. 1

Fig 2

INVENTOR,
Henry F. Bosenberg.
Per
Agent.
Orville M. Kile

THE FIRST PLANT PATENT

Figure 17

Facsimilie reproduction, slightly reduced, of the patent issued to H. F. Bosenberg for an improvement in climbing roses. The drawing, in black and white, shows the details of the "New Dawn" variety, which except for everblooming habit, is identical with the well known Dr. Van Fleet rose. The illustrations are reproduced from cuts kindly loaned by *The Journal of the Patent Office Society.*

Patented Aug. 18, 1931

Plant Pat. 1

UNITED STATES PATENT OFFICE

HENRY F. BOSENBERG, OF NEW BRUNSWICK, NEW JERSEY, ASSIGNOR TO LOUIS C. SCHUBERT, OF NEW BRUNSWICK, NEW JERSEY

CLIMBING OR TRAILING ROSE

Application filed August 6, 1930. Serial No. 473,410.

My invention relates to improvements in roses of the type known as climbing or trailing roses in which the central or main stalks acquire considerable length and when given moderate support "climb" and branch out in various directions.

In roses it is very desirable to have a long period of blooming. This has been acquired in non-climbing roses of the type ordinarily called monthly roses or everblooming roses. My invention now gives the true everblooming character to climbing roses.

The following description and accompanying illustrations apply to my improvements upon the well known variety Dr. Van Fleet, with which my new plant is identical as respects color and form of flower, general climbing qualities, foliage and hardiness, but from which it differs radically in flowering habits —but the same everblooming habits may be attained by breeding this new quality into other varieties of climbing roses.

Figure I shows (1) a flower that is just dropping its petals, (2) a bud about to open, (3) a terminal bud just forming on a large side shoot, and (4) a new shoot which has not yet finished its growth and formed buds at its terminus. This shoot would not appear on the branch illustrated until several weeks later than the stage of development shown, when it would grow out ordinarily from the axil of the first or second leaf below the bloomed-off flower. (5) shows a second way in which new flowering shoots form, by branching off on a short stem immediately or closely adjacent to the blossom that has just finished blooming. Figure II shows a further method of branching and bud formation in cases where the bloom has been cut off, but the formation of new flowering shoots is not dependent upon pruning off the old blossoms. It is evident that this succession of blooms continuously or intermittently supplied by new shoots branching out throughout the summer and fall gives the true everblooming character. When grown in the latitude of New Brunswick, New Jersey, my new climbing rose named "The New Dawn" and illustrated herewith in exact drawings from photographs, provides a succession of blossoms on a single plant from about the end of May to the middle of November, or until stopped by frost.

No claim is made as to novelty in color or other physical characteristics of the individual blossoms, nor as to the foliage or growing habits of this rose other than as described above.

I claim:

A climbing rose as herein shown and described, characterized by its everblooming habit.

In testimony whereof I affix my signature hereunto.

HENRY F. BOSENBERG.

SPECIFICATION AND CLAIM OF THE PATENT

Figure 18

A patent application contains a statement under oath that the invention disclosed in the specification (lines 1-58) and claims (lines 60-64) is the sole invention of the claimant. A patentable invention must have three characteristics. It must be new, it must be useful, and it must be an improvement in the existing art (technique) that would not be an obvious deduction, from existing knowledge of the art, to a person versed in the art.

proved and possibly unprovable statements in plant patent applications, but when they are made the basis of so broad a claim (Figure 18, lines 60-65) ("A climbing rose as herein shown and described") it may influence adversely the value of the plant patent law.

The Type Plant

If the law is to prove a benefit it must not offer unduly exclusive protection. Is Mr. Bosenberg entitled to a patent on "a climbing rose as herein shown and described, characterized by its everblooming habit?" Is he not entitled rather to protection on "climbing roses arising by asexual propagation *from the plant herein shown and described,* characterized by their everblooming habit?" In practice there might be a world of difference in the two claims. The broader claim appears to give him a monopoly on practically all everblooming bud variations or hybrids of the Walter Van Fleet which essentially resemble the parent form except in everblooming habit. Theoretically and practically to do this renders the plant patent law a travesty before it starts, because plants are variable, and there is only one way to bring this matter of plant patents to a focus, and that is by reference to the original plant, or to designated type plants, in the patent specifications. The originator may be given protection for the asexual propagation of the specific plant he has originated, or he may be given more or less mythical protection based on verbal descriptions, which because they are vague promise too much, and very likely in practice protect much less.

From the social point of view the distinction is very important. One form of patent protection is constructive—the other essentially destructive. The owner of a dozen or so vaguely defined patent claims can, if he has the right psychology and money enough to hire a lawyer, cause almost complete cessation of improvement of a given plant. Patents can be acquired by purchase, and not very many would be needed to work wholly unexpected and unjustified hardships

Conversely the actual linking of the claim to the specific plant gives the plant originator the protection he is entitled to—in a specific and definite form. His rose, *the one that he originated,* is being propagated. It is this that he wants to protect, and the law takes care of that. There is a remote possibility that an indistinguishable form might be originated independently. In the case of bud variations, as in the instance of Plant Patent 1, there is a distinct possibility that similar variations might occur repeatedly, as has happened in the case of the Thompson variation of the Washington Navel orange in California* and in other repeating variations.

Are Bud Variations Patentable?

This brings up the question of the patentability of fortuitous bud variations under the law. In the discussion of the law at the time it was enacted† it was pointed out that "discover," in the sense intended in the Constitution and in the present patent statute means to *invent* as the word is used today. Obviously Bosenberg in the "origination" of this new form was much more of a "discoverer," in the accepted sense of the word, than an "inventor." His contribution to the production of the new variety is in no way comparable to that of the originator of the Van Fleet Rose, who spent years of purposeful endeavor to produce the final form.‡ In Van Fleet's

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*See Shamel, A. D., et al. Bud Selection in the Washington Navel Orange. *Journal of Heredity* 16:233-241. 1925.

†*Journal of Heredity* 21:319-322 and 357-361. See especially pages 358-359.

‡"Moreover, it is to be noted that the committee has, by its amendment in striking out the patenting of 'newly found' varieties of plants, eliminated from the scope of the bill those wild varieties discovered by the plant explorer or other person who has in no way engaged either in plant cultivation or care and who has in no other way facilitated nature in the creation of a new and desirable variety."—Senate Committee report on plant patent law.

contribution we have real inventiveness applied to plant breeding—in distinct contrast to what Bosenberg displayed in noticing that one plant was different from its fellows, and in propagating it.

Another angle that undoubtedly will be considered by the courts is the basic principle of patent law that a patent must represent an improvement that is not an obvious development to a person "skilled in the art." For example, a patentable invention is not deemed to exist when a mechanic increases the rigidity of a machine by the addition of struts and braces. Similarly it might be argued that persons skilled in the art of horticulture have for several thousand years made a practice of propagating aberrant plants that appear spontaneously in their gardens, and that the propagation of a new form appearing as a bud mutation is not an instance of inventive faculty, but an obvious procedure to anyone "skilled in the art."

The only way to test such features of the plant patent law is, of course, to grant the patents and let the matter take its course through the courts. When this is done, it is probable that the courts will construe the law in the light of existing patent decisions, applying these where they *seem* to fit. The granting of patents on bud variations might be argued either way from the point of view of agricultural expediency, but if such patents are held to be valid it would seem to represent a drastic revision of existing concepts of what constitutes inventive faculty, which is the faculty assumed to be stimulated by patent protection.

A Patent an Embodied Idea

In this connection it must be borne in mind that the Courts have consistently held that a patent is essentially *the physical embodiment of an idea.* The *idea* is the basic and essential part of every patent. In many instances new varieties of plants represent just what has heretofore been protected by patent, and as such are clearly patentable. The Van Fleet Rose and this "New Dawn" variation are an excellent example of the distinction. One represents an embodied idea, persistently striven for; the other represents an "accident" and a little forethought—nothing more. It may well be questioned whether the Courts will revise their views with regard to this matter to fit the new patent law. Unless there is a complete reversal in this matter, the validity of Plant Patent 1 might also be questioned because of the notable absence of the inevitable brainstorm that is said to be an essential concomitant of every patent. This has no general bearing on the constitutionality of the plant patent clause as a whole, but it might limit the application of the law to valid instances of plant inventions—not to entirely casual "discoveries."

"Products of Nature" Not Patentable

The reaction, if any, of the new patent legislation on the courts is perhaps reflected in two decisions rendered since the law was adopted. In the case of the patentability of ductile uranium the U. S. Court of Customs and Patent Appeals rendered a decision in the following terms: "Uranium is a product of nature, and applicant is not entitled to a patent thereon nor upon any of its inherent natural qualities" (in Re. Marden 409 O. G. 559). On the same principle patents have been denied on ductile tungsten and ductile thorium, on polished oyster shells, and on oranges treated with borax. The latter decision was rendered by the United States Supreme Court on March 2, 1931, nearly a year after the plant patent law was enacted. In this case, involving very large interests, the Supreme Court reversed the decisions of lower courts and held that an orange dipped in a solution of borax to render the skin mould-resistant was not a manufactured article, and hence not patentable. There has always been a clear distinction maintained between products of nature and manufactured articles.*

Whether varieties derived through the exercise of the plant breeders' art

*The statute reads: "Any person who has invented or discovered any new and useful art

will not also be considered products of nature in the same sense as are products of ductile tungsten, a substance not known to occur naturally, remains to be determined. In the last analysis, all chemical and physical properties are inherent in the elements, and therefore "natural." It is a little hard to distinguish the natural property of tungsten that renders it ductile under certain conditions from the natural properties of carbon and hydrogen and oxygen that permit them to combine in various ways to form a vast array of patentable chemical compounds. Unquestionably the genetic elements which go to make up a new form of plant are "natural." Into which category of "naturalness" the courts will conclude that these phenomena of plants should be placed in an extremely interesting problem.

Experiment and "Unexpected Results"

In the field of chemical patents another set of principles appears to apply. Many chemical patents have been granted for combinations that produced unexpected results. In fact, decisions in some of the lower courts have advanced the principle that, in substitution of one material for another in a chemical compound, the new compound is not patentable unless an "unexpected result" be obtained. This seems to be diametrically opposed to the concept that the idea is basic in a patent. An unexpected result is obviously one that occurs in the absence of a deliberate plan or in spite of it. Opposed to this view, the Supreme Court has held that "it does not detract from its [the invention's] merit that it is the result of experiment and not the instant and perfect product of inventive power." The analogy between this situation in chemistry and the production of new plant varieties is striking. While a chance bud variation may be considered to be a natural product, a variety that represents years of application and a great number of experiments with different combinations of plants represents certainly an outcome that can hardly be considered "natural" by any reasonable test.

The importance of bud mutation in the production of new varieties is a somewhat debatable question. In many instances the varieties produced by bud mutation have been variations in color or shape of existing forms. Even if it were held that bud mutations were not patentable for either of the above reasons it would leave the larger field of improvement, that of the production of new forms by hybridization and selection, still subject to patent protection.

It has been suggested that the most important contribution that radiation-induced mutations will make to plant breeding is in the field of asexually reproduced plants.* Bud mutations induced by X-rays may be propagated asexually and without regard to lethals and chromosome derangements which would make sexual propagation difficult. One who induces mutations, even though he is not sure just what he is going to induce, is after all definitely experimenting, and the product could hardly be called "natural." A new variety produced by such means is perhaps more an "invention" than one which is found ready to hand in the back yard.

It is hoped that these speculations on some of the complexities that are almost certain to arise in administering the plant patent law will emphasize an important fact. Past decisions with regard to patent law seem in many instances to be diametrically opposed to each other. It is still an open question which of these principles will be

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machine, manufacture, or composition of matter, or any new and useful improvements thereof, *or who has invented or discovered and asexually reproduced any distinct and new variety of plant other than a tuber-propagated plant*, not known or used by others in this country, before his invention or discovery thereof.* * * * * *

*Stadler, L. J. *Journal of Heredity* 21:31-19. 1930.

deemed to apply to plants. An intelligent understanding by plantsmen of the legal complexities which may arise in construing the law is thus a matter of the utmost importance. It would be a calamity to let the early decisions with regard to the plant patent law be made without clear statements by those "skilled in the art" of plant improvement as to what form of patent protection can be expected to stimulate most effectively the art of the plant breeder.

A plant with a new character may be a valuable discovery, but it is not a formula or a contrivance. Nevertheless inventive genius of a high order is often displayed in the production of new forms. New plants may be sought diligently in nature or by making large numbers of artificial hybrids, after the methods of Burbank and Van Fleet, selecting a few desirable forms and destroying great numbers of worthless individuals. The art of the breeder lies in knowing what to look for, and in having the interest to look; and in skill and persistance in the making of crosses. The practical question now to be determined is whether the interest in plant improvement can be rewarded and stimulated through the granting of patents. Much of the success or failure of this experiment, which was only just begun by the amendment of the law, depends on the details of its application, practically all of which have yet to be worked out.

—Robert C. Cook

THE INHERITANCE OF RUBY SEED COAT COLOR IN PEAS

L. M. Dickerson

The Blandy Experimental Farm, University of Virginia

AMONG the pigmented seed coat colors in garden peas (*Pisum sativum*), "Ruby" is unique in that the color characteristic of the mature testa is recognizable in the very young and immature ovules. This color is a rich dark red in the dry testa and appears as a translucent dark red in the immature seed coats. Ruby is distinct from, and is in no way to be confused with the orange brown seed coat color described by Tschermak[2], or with the reddish brown discoloration of gray seed coats occurring under certain moisture and temperature conditions.

Literature

Although the variety is an old one and the "Ruby" character is known to several of the students of heredity in peas, no reference to it appears in the literature. White[5] does not list it either from references or as a part of his own experimental work. Neither do Sverdrup[1] nor Wellensiek[4] mention the character in their papers summarizing the knowledge of heredity in the genus *Pisum*.

Materials and Methods

The materials used in these experiments were obtained from Dr. Orland E. White, to whom the author is indebted, also, for valuable criticisms and suggestions as well as for library facilities. Originally, this variant race came from Vilmorin & Cie, Paris.

In the spring of 1928 several crosses were made between the variety of peas called Ruby and varieties having gray seed coats. Both the Ruby and the gray seed coated strains had been grown as pure cultures for several generations and had bred true for red-purple flower color as well as for the seed coat characters. The variety Ruby

also carried the factor *F* for the specking pattern of the seed coat. This specking pattern does not contrast strikingly with the dark red seed coat and may easily escape notice except on careful inspection. This is particularly true if for any reason the seeds are shriveled or malformed. Several plants were encountered in the F_2 populations on which numerous shriveled, poorly filled seeds showed no specks, yet all of the well-filled seeds of these plants showed at least a few dots.

Experimental Results

In the F_1 generation, the immature seed showed the Ruby character in a somewhat diluted intensity but still distinct. In the dry testas the seed coats were gray to brownish red (the latter a weathering characteristic of gray seed coats) rather than the usual dark red to maroon color of the homozygous Ruby. The F_1 was also specked.

The results of segregation are shown in the F_2 distribution given in Table I.

From this table it will be seen that the monohybrid ratio of 277 Gray or non-ruby: 80 Ruby accords fairly well with the calculated expectation of 267.7:89.3. The distribution of speck and non-speck is quite otherwise, the observed numbers being 238:119 or 2:1 against the expected 3:1 F_2 frequency of 267.7:89.3.

The difficulties in classification previously mentioned, account for these results, as the inheritance of this pattern has been fairly well investigated. The discrepancy in Table I between the observed and calculated is mainly due to the factors concerned with specking.

In the cultures represented by the first two distributions in Table I, many plants produced only a few seeds and in some cases these were defective. This may have resulted in some plants being classified as non-speck which, with better seed, would have appeared as speck.

Discussion

The character Ruby in this discussion is designated *Ru*. Since the genetics of seed coat color in Pisum is very imperfectly understood and there are many color relations to be worked out, the symbols *Ru* (Ruby) and *ru* (non-ruby) are to be regarded as tentative. On this basis the factors of the Ruby strain used in these experiments are indicated by *Ru F*, the gray seed coat strains as *ru f*. In the absence of *Ru* the seed coats are gray. All strains carried the same flower pigment factors. The relation of Ruby to white flower and colorless seed-coat races is unknown, though presumably *Ru* expresses itself only when the flower pigment factors are present, since this is true of all but one of the previously investigated seed coat colors in Pisum.

Table I, giving the F_2 ratios indicates that *Ru* and *F* are independently inherited. In cross III of the table, the observed numbers give a very close approximation to a typical 9:3:3:1 ratio. In the other crosses the discrepancies have already been discussed.

The most interesting aspect of the

TABLE I—Segregation of Ruby=gray, Specked=Non Specked in F_2

Cross	Pedigree	Observed and Calculated	Gray Spk.	Ruby Spk.	Gray Non-spk.	Ruby Non-spk.
I	Ruby x 50	O	52	8	18	8
		C	48.4	16.1	16.1	5.3
II	Ruby x 86	O	63	17	49	13
		C	79.9	26.6	26.6	8.9
III	Ruby x 161	O	73	25	22	9
		C	72.0	24 0	24.0	8.0
	Totals	O	188	50	89	30
		C	200.7	66.9	66.9	22.3

Ruby character is its more or less dominant expression in the immature *Ru ru* seeds and its practically recessive condition in the mature *Ru ru* seeds. The expression of *Gc* (Gray seed coat color) in the mature seeds of the combination *Ru ru* is probably epistatic, since only at maturity does *Gc* express itself.

Summary

Ruby, a seed coat color of Pisum, appears to be independent in inheritance from specking (*F*).

Ruby is tentatively designated *Ru*, its allelomorph *ru*.

Ru is dominant in the F_1 during the immature stages of seed development, but segregates as a "recessive" in the mature seed coats of the F_2.

The ruby seed coat color, being visible in the immature seed coats, and masked by the later appearance of the gray character, gives the appearance of a reversal of dominance. The masking of Ruby in mature *Ru ru* seeds by *Gc* may possibly be interpreted as epistasis on the part of *Gc*.

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What Governs Population Growth?

AN HYPOTHESIS OF POPULATION GROWTH *by* Ezra Bowen. No. 343, Columbia Studies in History, Economics and Public Law. Pp. 238. Price, $3.75. Columbia University Press, New York. 1931.

THE countless volumes on population, which have appeared since Malthus' essay catapulted the study of population growth from the cloister of academic innocuousness into the forum of economic importance, fall into two classes: (a) statistical studies of population trends and correlations; and (b) bioligico-economic interpretations of the statistics of population growth. In the present volume, which falls in class (b), Professor Bowen, who has examined close to 300 works touching on population growth, passes in critical review many of the leading population theories from Malthus to Raymond Pearl and derives therefrom a formula or hypothesis of population growth, and a number of interesting conclusions relative to the future of population growth.

It is the author's contention "merely that forces and influences operating upon the growth of population may be reduced to two overwhelmingly significant—and perhaps all-inclusive—factors, wealth and living-standards, and that a formula predicated on these two factors should prove helpful in promoting an understanding of the intricacies of population growth" (Preface). Increases in wealth further the growth of population while increases in living standards check population growth. "Populations tend to increase, directly with wealth, and inversely with prevailing levels of living standards" (p. 23). Or, if one may put this proposition in statistical form, $\frac{\text{Wealth}}{\text{Living Standard}}$ fixes the population for fairly large geographic areas. The statistically minded must remember,

however, "that our formula does not pretend to possess absolute mathematical integrity; it pretends only to offer a clear statement of the way in which population growth is related, directly and through psychological channels, to its obviously fundamental correlatives, wealth and its distributions" (p. 213).

On the basis of this formula coupled with current trends Professor Bowen concludes that: (1) Since the growth of world population will soon be stabilized at a level perhaps below existing totals man need not fear starvation because of overpopulation. (2) Since further increases in wealth will not be accompanied by increases in population "the large probability is that leisure and standards of living will reach levels unimagined." (3) The white race will prevail. (4) Modern poverty springs from overpopulation in the under-endowed classes and "may be eliminated from human life." (5) Birth control will win official recognition everywhere. (6) "Systematic control of population growth will reduce, but will not eliminate the possibility of war. (7) There is no danger that man's future is endangered by any dilution of his biological reproductive capacity. (8) "Excepting brief periods and restricted areas, the 'dysgenic' trend in birth rates has never been effective in lowering population quality; with universal birth control established the trend of the birth rate will not only lose its dysgenic appearance but will become pronouncedly eugenic; there will be a consequent speeding up of the biologic progress of human kind." (pp. 221-22).

II

In our opinion, although Professor Bowen always argues cogently and with facile grace, his main thesis and several of the conclusions are open to criticism. The term standard of living has two distinct meanings which Professor Bowen recognizes but does not adequately incorporate into his argument. Standard of living may mean the actual expenditures or *scale of life* maintained by individuals. Or more accurately used *Standard of living* may comprehend not only the order of expenditures actually realized but also what the individual hopes for and considers necessary to the full realization of social status and satisfaction. To complete a theory that population increases inversely with the level of living standards it is necessary to take account of: (a) the effect upon the birth rate of the difference between the scale of life the individual maintains and the standard he would like to maintain; and (b) the evolution in different social groups of the standards in accordance with which individuals would like to live. Stated statistically one could say that the birth rate is a function of $\frac{\text{Standard-Scale}}{\text{Scale}}$. Birth restriction, in short, is but an expression of restiveness, of the fact that realized income falls short of providing the individual with what he deems necessary to personal well-being.

The scales of living maintained in high income groups determine the tastes and fix the standards of the lower income groups in a democratic civilization because, as a result of the existence of free inter-class channels for the communication of tastes and practices, the lower income groups can observe how the higher income groups live. The birth rate, accordingly, is affected by prevailing distribution of income. A considerable part of each individual's life is given to a usually futile effort to bridge the gap which separates the standard of life from the scale of life. Marriage usually, and to a far greater degree, the raising of a family, is but a handicap to the bridging of this gap. Accordingly, if at any time the birth rate is too low, an increase in births can be promoted by offering to potential parents endowments which more than cover the expenses of raising a family and thus contribute to the destruction of the spread between the scale and the standard of living.

Our criticism of Professor Bowen's formula boils down to the fact that the term standard of living is not given a

determinate meaning. A similar criticism could be made of his use of the term "wealth." Accordingly, even though one admits the general truth of his formula: $\text{Population} = \frac{\text{Wealth}}{\text{Living Standard}}$ solution of this formula would not yield a very determinate answer, nor clarify sharply the source of the psychic processes which underly family limitation.

Of the conclusions reached by Professor Bowen (2) and (5) are overly optimistic, (4) neglects to a large degree the effect of institutions upon wealth distribution, (6) is loosely stated and does not follow clearly from the argument of the book, and (8) is open to much question. He argues that the differential birth rate is offset "or rather, reversed, by the production of favorable variants in inferior classes and by a differential death rate" (194). Of this, except as concerns the most inadequately endowed classes, he offers no proof. Widespread differences in fertility between social classes constitute a recent phenomenon.* A century ago net fertility may have been greater among the more able classes. Today this is not the case nor is there convincing statistical evidence that differences between the net fertility of the upper and the lower socio-economic classes is disappearing. Democracy has permitted the able members of the lower economic classes to scale the ladders of opportunity with ease. These rising individuals today enter the relatively sterile classes whereas a century ago they preserved both their fitness and their fertility lower down in the economic scale. Furthermore, to some extent physiological infertility tends, through the selective process, to become coupled with other traits making for success in a capitalistic society. One is inclined to conclude with R. A. Fisher that "the composition of existing populations, graded both in social ability and in effective infertility, presents special, and much graver difficulties, which only a people capable of deliberate and contentional policy could hope to overcome."† To overcome this situation requires more than buoyant optimism. The whole argument of the present volume could have been improved by an examination of the writings of Bertillon, Dumont, Gounard, Kyrk, Sorokin, Sumner, Stevenson, and Veblen.

JOSEPH J. SPENGLER.

* See Stevenson, *Journal of Royal Statistical Society*, Vol. 83, 1920, pp. 431-32.
† The Genetical Theory of Natural Selection, p. 265.

Inheritance of Induced Melanism in Moths*

A FEW years ago Professor J. W. Heslop Harrison announced that melanism had been induced in moths of the genus Selenia by feeding the caterpillars on foliage impregnated with salts of manganese and of lead. The experiments were initiated by the observation that moths in industrialized regions in England were believed to be darker than the members of the same species in rural areas. This relation between the number of factory chimneys and the intensity of coloration in moths had been noted both in England and on the Continent. The experiment consisted in feeding moths of rural origin, and therefore presumably non-melanotic, with naturally factory-contaminated foliage, and with foliage artificially impregnated with lead nitrate and manganese sulphate, as these elements were found frequently in the

* HARRISON, J. W. H., and GARRET, F. C. Introduction of Melanism in Lepidoptera. *Proc. Roy. Soc. B.*, Vol. 99. 1926.

fumes of the industrial regions in which the melanotic moths were observed. *Selene bilunaria,* the English Thorn moth was used, and in the third generation from lead-treated caterpillars melanotic individuals were first observed. This melanism was inherited as a Mendelian recessive. No melanism was observed in the wild species, which does not occur naturally in the region where the experiments were carried out.

In a communication to *Nature* [London] (128:496, Sept., 1931), Dr. A. W. McKenny Hughes of John Innes Horticultural Institution reports a repetition of this experiment in which no melanism was observed in the treated moths. Three families of Selenia from three locations were inbred for two generations to test for recessive melanism. After this the three lines were separated into a control group and two groups to be fed on lead-treated and on manganese-treated foliage respectively. In all 1,472 lead-treated, 283 manganese-treated and 1,231 control moths have been reared, and no signs of melanism has appeared in any of the moths. Analysis showed that lead was present in the last generation of moths to be reared.

In other species Harrison and Garrett reported the induction of dominant melanism in moths of another genus (*Tephrosia crepiscutlaria*) by feeding with naturally contaminated foliage. Hughes' experiment, being negative, and only dealing with a single species, hardly disposes of all of Harrison's observations and results, but it raises a question of whether lead or manganese are the irritating substances, and a further question as to the possibility of the previously reported "induced mutation" being due to genetic impurity of the stock or to chance mutations. Coincidences, unfortunately, have occurred and do occur in the most unexpected and disconcerting places.

Exploring for Plants

EXPLORING FOR PLANTS, *by* DAVID FAIRCHILD. From Notes of the Allison Vincent Armour Expeditions for the United States Department of Agriculture, 1925, 1926, and 1927. Pp. XI+591. Illustrated. The Macmillan Company, New York, 1930.

Plant hunting in the remote regions of the globe has been the subject of several interesting books published since the beginning of this century. The volumes written by that dean of plant hunters, Ernest H. Wilson, and by his fellow-countryman, Captain Kingdon Ward, have brought to the attention of horticulturists many new species, and have entertained us with their tales of adventure.

Though its title places it in the same general field, Dr. Fairchild's book is of different character from others which have been written on plant hunting. The author explains, in his first chapter, "Throughout the whole three years of wandering, my eyes have been more or less alert to the passing show of foods which have been offered me on the tables of the countries through which we travelled and if there is any one 'golden thread' to this narrative, it is the thread of the food habits of the world."

From this it might be assumed that the consideration of food-habits constitutes the book's chief topic of interest. Far from it. Though food-habits may form the golden thread, it is a thread which appears and disappears as one turns the pages of the volume, to give place here to an interesting description of ornamental or useful plants seen along the wayside, there to a brief consideration of Moroccan architecture or the mingling of races in the Asiatic tropics; while the author's reminiscences covering his long career of plant introduction, and his mention of personali-

ties met during the course of the travels which form the background of the book, keep one interested, and guessing what he will find on the next page.

The voyages, of which Dr. Fairchild's personal notes are here brought together in book form, were those of the Yacht *Utowana,* outfitted by her owner, Allison V. Armour, expressly for the purpose of poking into corners off the beaten track, and equipped to care for seeds and plants until they could be brought or shipped back to the United States. The itinerary was a lengthy one, including England, Belgium, France, North Africa, Portugal, southern Spain, the Canary and Balearic Islands, Ceylon, Sumatra, Java, the Straits Settlements, and the West Coast of Africa.

In nearly all these regions, Dr. Fairchild's notes are as much of plantsmen as of plants. At Kew "There was Burtt Davy, buried among the plants of South Africa; and Foxworthy, writing up the trees of the Malay Peninsula, of which there are more species, twice over, than there are flowering plants in the British Isles; and the Emeritus Curator of the Herbarium, Stapf, who is struggling to finish his descriptions of the grasses of Africa; and Ridley, that veteran of plant introduction, whose keen intelligence and persistence had so much to do with the establishment of the rubber industry in the Orient, hard at work finishing his flora of the Malay Peninsula."

As the author continues his journey through Europe, the reader enjoys accounts of his visits with such famous plantsmen as Lehaie in Belgium; Professor Bois and the members of the house of Vilmorin at Paris; and above all, that veteran plant breeder, who has since died, Pernet Ducher:

> In Paris we were told that he lived at Vennissieux, a village a few kilometers from St. Fons. We inquired at the square in Venissieux and were given vague directions. We stumbled about for the better part of an hour, discovering that nobody knew anything about M. Pernet Ducher. It was a factory town, with surroundings as unattractive as those in the suburbs of Jersey City. It was hard to believe that we were in the environment in which lived the man who had produced such superbly beautiful denizens of the flower garden. At last we found the place and rang the bell at the simple iron gate and a pretty young girl admitted us to the yard. There were no evidences of our being in any other than one of the thousands of little houses just like this one, shut in from the ugly street with a high stone wall. An old unused hothouse, a single spruce tree, no sign of a garden.
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> The girl ushered us into the room where Pernet Ducher sat working. He seemed a bit startled to be taken unannounced by three American visitors. He sat at a plain deal table in his simple working costume with little piles of yellow plant labels beside him. We spoke at length of Van Fleet, whose roses he knew. . . . . I remarked that in America we were coming to feel that there were perhaps fewer plant breeders now than there were twenty years ago, and he said, "unfortunately it is the same in France." Then Mrs. Fairchild asked him if he had anyone who would follow him. "No. I had two sons but they both fell in the war." With these words he dropped his hands in his lap in a pathetic helpless way, and we saw that we had touched the subject closest to his heart. . . . . The whole surroundings and the man made a deep impression upon me, the impression of a solitary man working alone.
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> A desk in the corner was littered with papers and on the wall hung a diploma and a photograph of a hothouse in England full of roses, doubtless roses of his production. The haggard look on his face was relieved by piercing dark eyes, and when he spoke his French was the cultivated French of a gentleman. I told him I had come to pay my respects to him as the greatest rose breeder in the world.

The plants which are mentioned or briefly described number several hundred. A study of the mangosteen and its relatives formed one of the major objects of the expedition to the Malayan region. Dr. Fairchild therefore spent some time going through the herbarium material of this genus at Kew Gardens; later he describes and depicts several forms which were collected in Sumatra and Java. The Argan tree of Morocco came in for a good share of attention, as did the gigantic mild flavored onion of Iviza in the Balearic Islands. Interesting observations were made regarding the cultivation of the

carob or St. John's bread tree in southern Spain, and regarding the scarcity of avocados in this region and in southern Italy. A few specimens found here and there show that the climate is suitable, but in spite of at least a hundred years which have passed since its introduction, the avocado has not become as popular as it has in the United States, where it has hardly been known a fourth of that time. The bael fruit and the honey jak were collected in Ceylon, both appearing worthy of more attention than they are at present receiving in other parts of the tropical world. The rapidly-developing oil palm industry in Sumatra is described, while several pages are devoted to the magnificent bamboos of Java and their multitudinous uses. Two fruits of this region which proved interesting are the Javanese pummelo and the mysterious keppel, which latter Dr. Fairchild mentions in a whisper, as it is "a great favorite with the ladies of the sultan's harem." On the West Coast of Africa the native oil palms received much attention, as did also several species of Combretum, — handsome ornamental shrubs, — and the "miraculous tree," *Synsepalum dulcificum*, the fruits of which possess the extraordinary property of making anything you put in your mouth taste sweet.

One hundred and eighty photographs, taken by the author or by other members of the party, serve to illustrate many of the plants described, together with their uses. Rarely has so interesting a collection of pictures been brought together in a work of this size; it is regrettable only that more of them could not have been used as full-page illustrations.

Dr. Fairchild's extensive background of experience,—more than a quarter century in charge of the Office of Foreign Plant Introduction, U. S. Department of Agriculture, which office and work he organized, inspired at the beginning by the vision and enthusiasm of Barbour Lathrop,—brings a mature understanding to the evaluation of little-known crops, and a keen appreciation of their possibilities. It also means that, in pursuing his "golden thread," Dr. Fairchild cherishes no illusions regarding the difficulties which accompany the popularization of new food plants, difficulties much greater than those of transplanting them to new homes half way around the world. "I have rather come to the opinion," he writes, "that there is something fortuitous about this matter of new foods. I do not think the fact that a new food lies unnoticed for many years in a country has any deeper significance than that there is no machinery for its popularization,—no method of making it pay its own way."

WILSON POPENOE.

Variation and Evolution

ENCYCLOPEDIE SCIENTIFIQUE, BIOLOGIE GENERALE, La Variation & l'Evolution, Volume 2; L'Evolution, by Professor E. Guyénot.

WE need more books of this sort. Guyénot has given us a clearly presented review of the field of evolution. It is more than a review because it contains much that is original. However, its greatest ahievement is due to the uncanny ability of the author to present the work of another in a way that clearly shows its scope, its strength and its weakness, and to do all this in ten or a dozen lines. Much of the evidence is drawn from observations on animals. This results in an added interest to plant students, as it affords a slightly different viewpoint.

The material is arranged to fit the author's conception of evolution, but he does not hesitate to point out the difficulties in the way of establishing the theories he favors.

H. V. HARLAN.